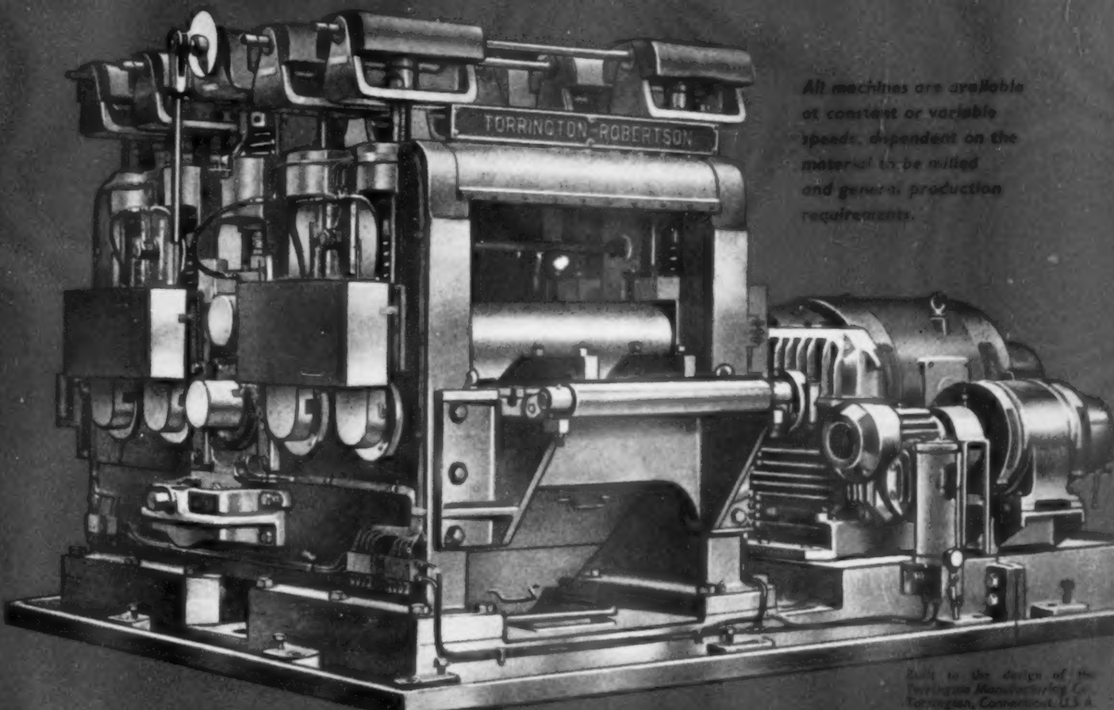
Sheet Metal Industries

The only Journal in the World wholly devoted to the Manufacture, Manipulation, Fabrication, Welding, Assembly and Finishing of Ferrous and Non-Ferrous Sheet and Strip

VOL. 38 : No. 407 **MARCH 1961** **PRICE 2/6**

ROBERTSON

Slab Milling Machines are manufactured in a standard range of sizes suitable for overhauling non-ferrous strip from 6 in. to 44 in.



All machines are available at constant or variable speeds, dependent on the material to be milled and general production requirements.

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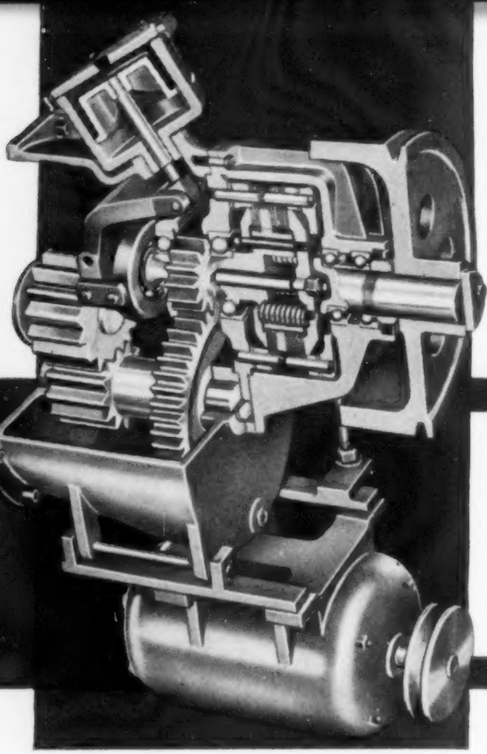
LICENSEES FOR THE BUILDING OF SENDZIMIR COLD REDUCTION MILLS AND PLANETARY HOT MILLS AND HALLDEN FLYING SHEARS.

WT. 568



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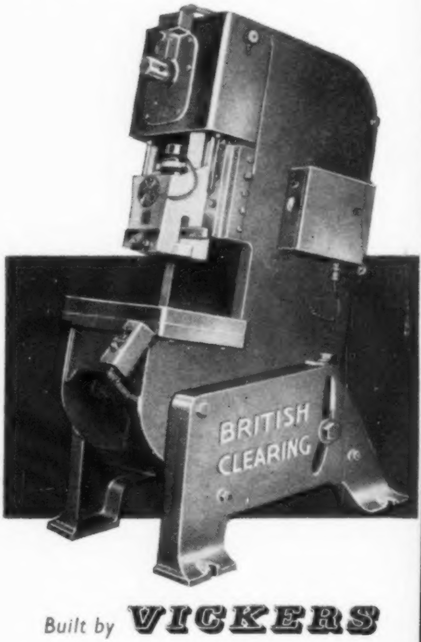

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DRIVE UNIT GUARANTEED FOR 18 MONTHS

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WELDED STEEL FRAMES GIVE BIG VARIETY OF SIZES

MINIMUM FLOOR SPACE

CENTRALISED OIL LUBRICATION

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INCLINING ADJUSTMENT BY SINGLE SCREW

22, 32 & 45 TON MODELS

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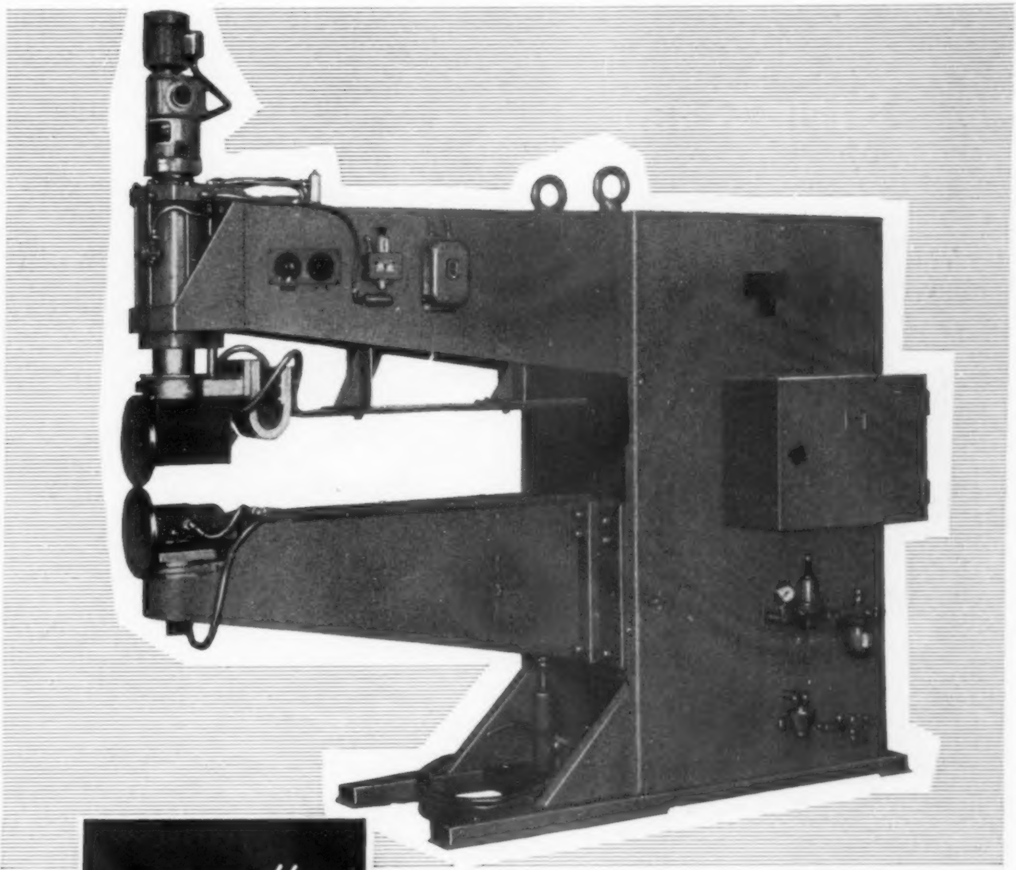

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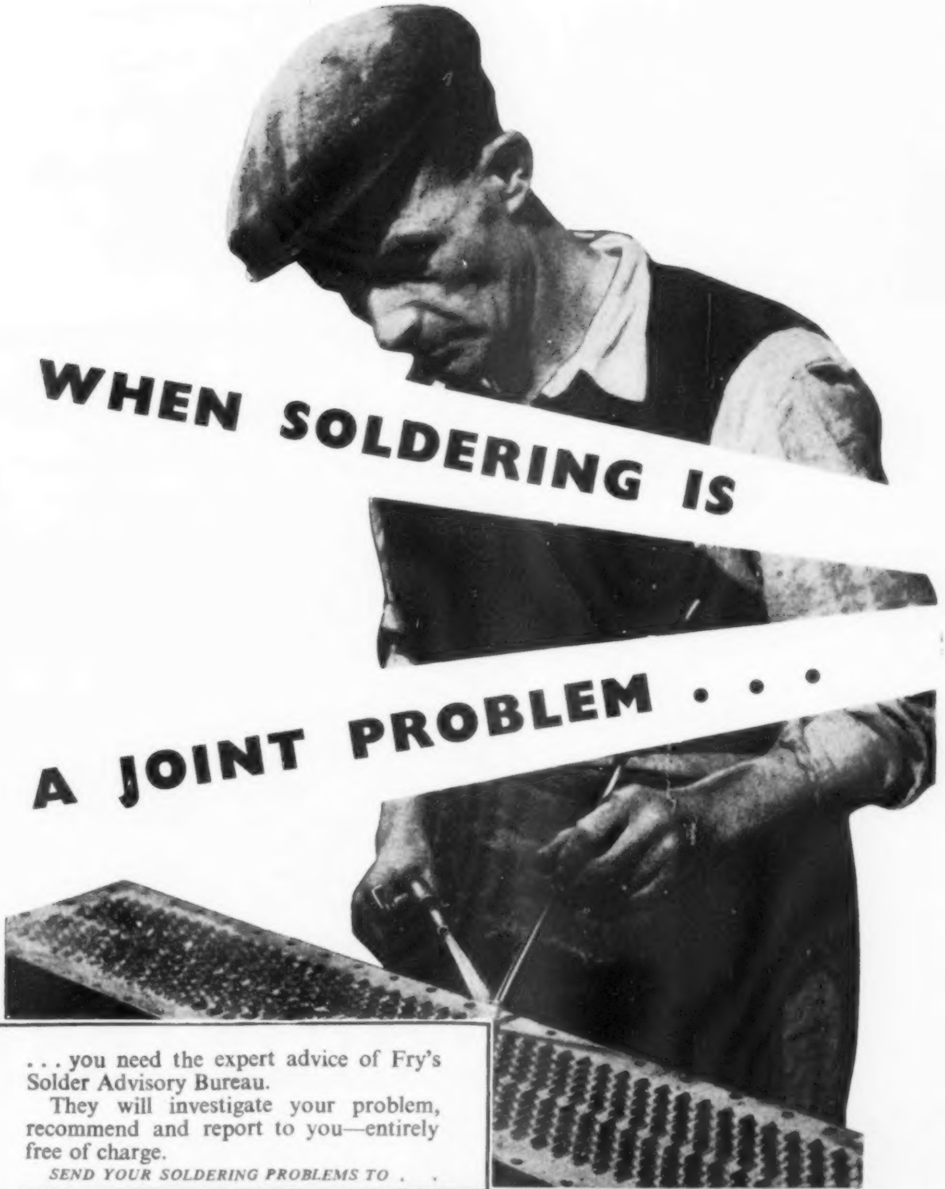
A hydraulic circular type



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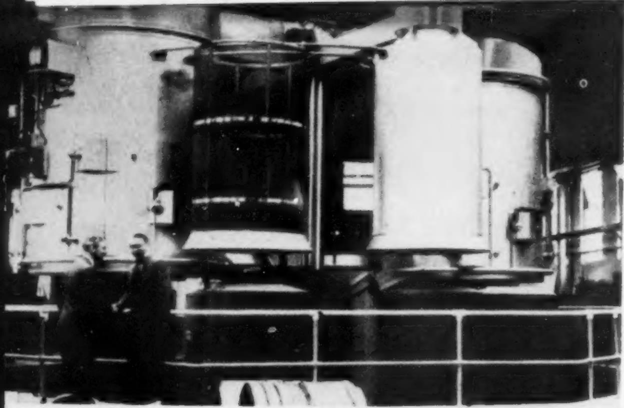
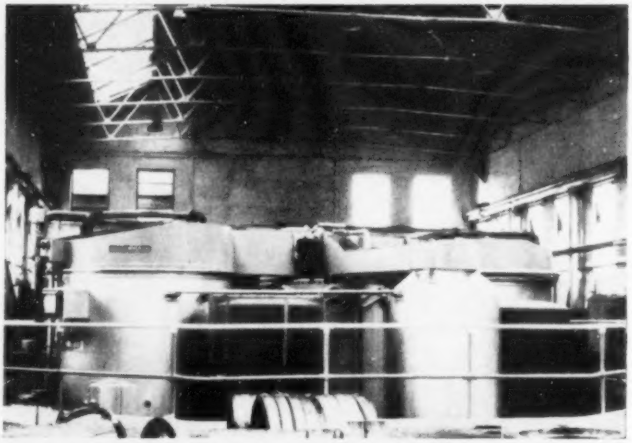


A hydraulic circular type annealing furnace for coils up to 48″ diameter—gas fired—installed at

J. J. Habershon & Sons Ltd. Rotherham.

Furnace in raised position

GRUENEWALD



This furnace was installed in May 1960. A second furnace is to be working in April, and a third in September 1961

Furnace in lowered position

F.W. KUBACH LTD

Part of instrument panel

F. W. KUBACH LTD.

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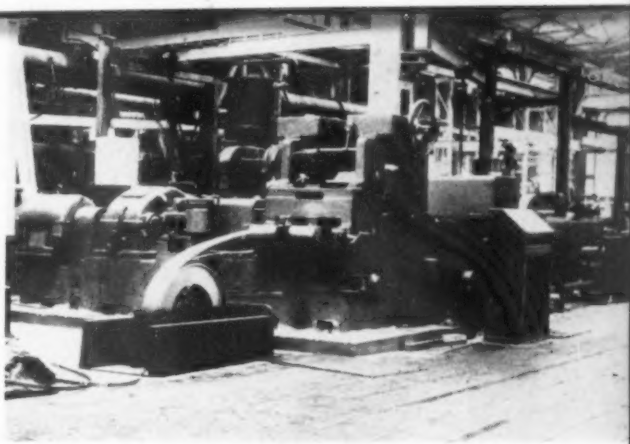
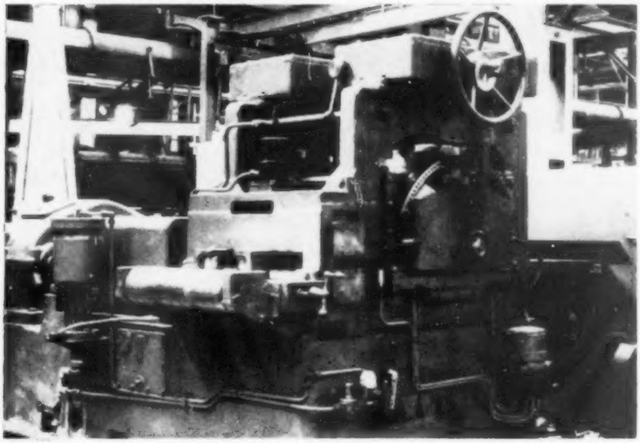
These photographs are of equipment working in production

R.W.F.





A leveller and cutting up line running at up to 200 ft. per minute

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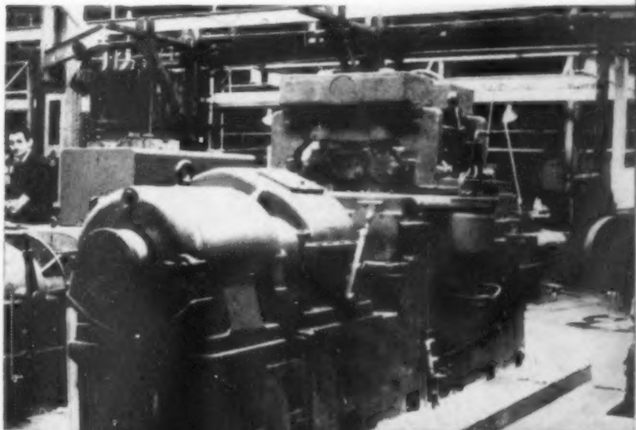

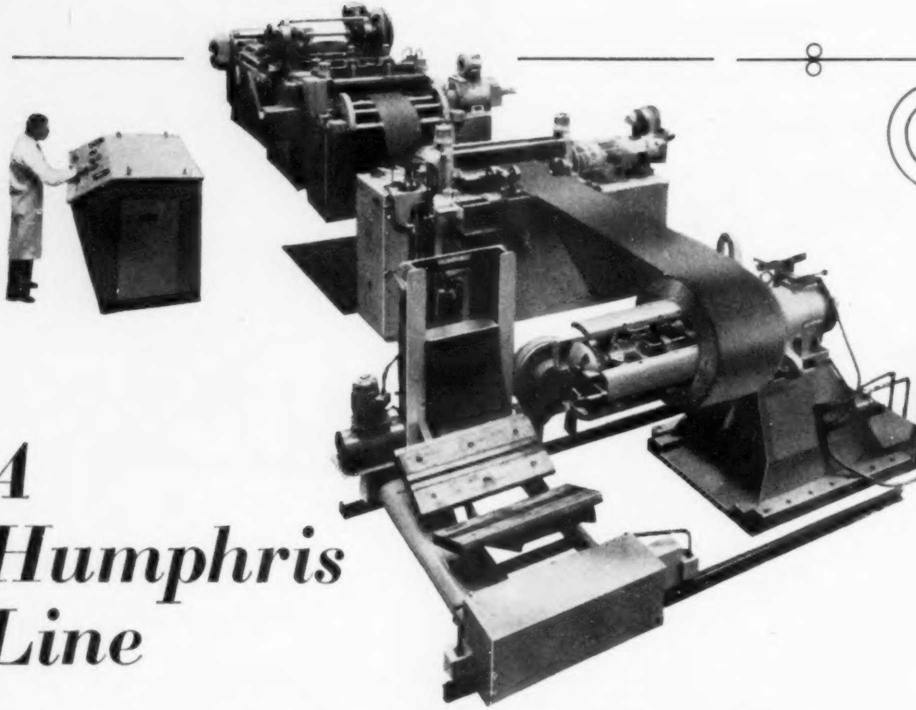

A Humphris Line

for cutting to length

COLD ROLLED GRAIN ORIENTED SILICON STEEL

for Power Transformer Core Plates

3 ton coils—lamination lengths between 7 inches and 12 feet—widths between 2 inches and 36 inches—a peak strip speed of over 300 feet per minute—lengths within tolerance of .010 inches—first sheet to tolerance each time!
All this was achieved in the line illustrated and is typical of the performance attained in the dozen or more lines built for large transformer manufacturers during the last three years.

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PAINT—a smooth, matt or glossy film of stove enamel.

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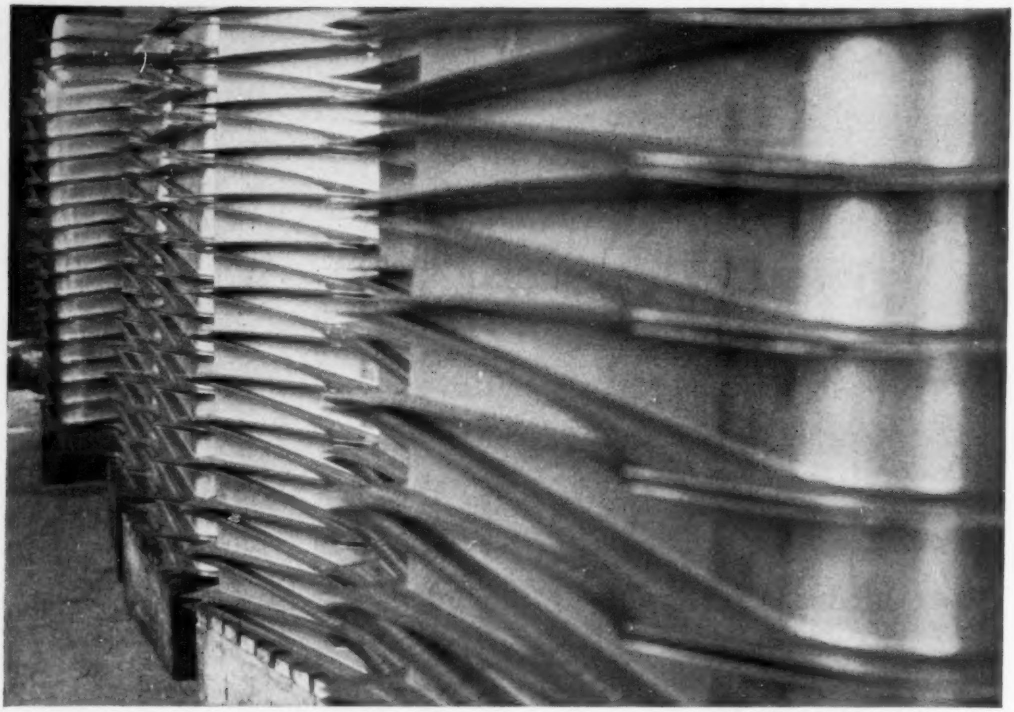

Photograph by courtesy Lec Refrigeration Ltd

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These are some of the industries in which Dragonite is being used extensively: Domestic Appliances; Electrical Industry; Automobiles; Radio Equipment; Office Furniture.

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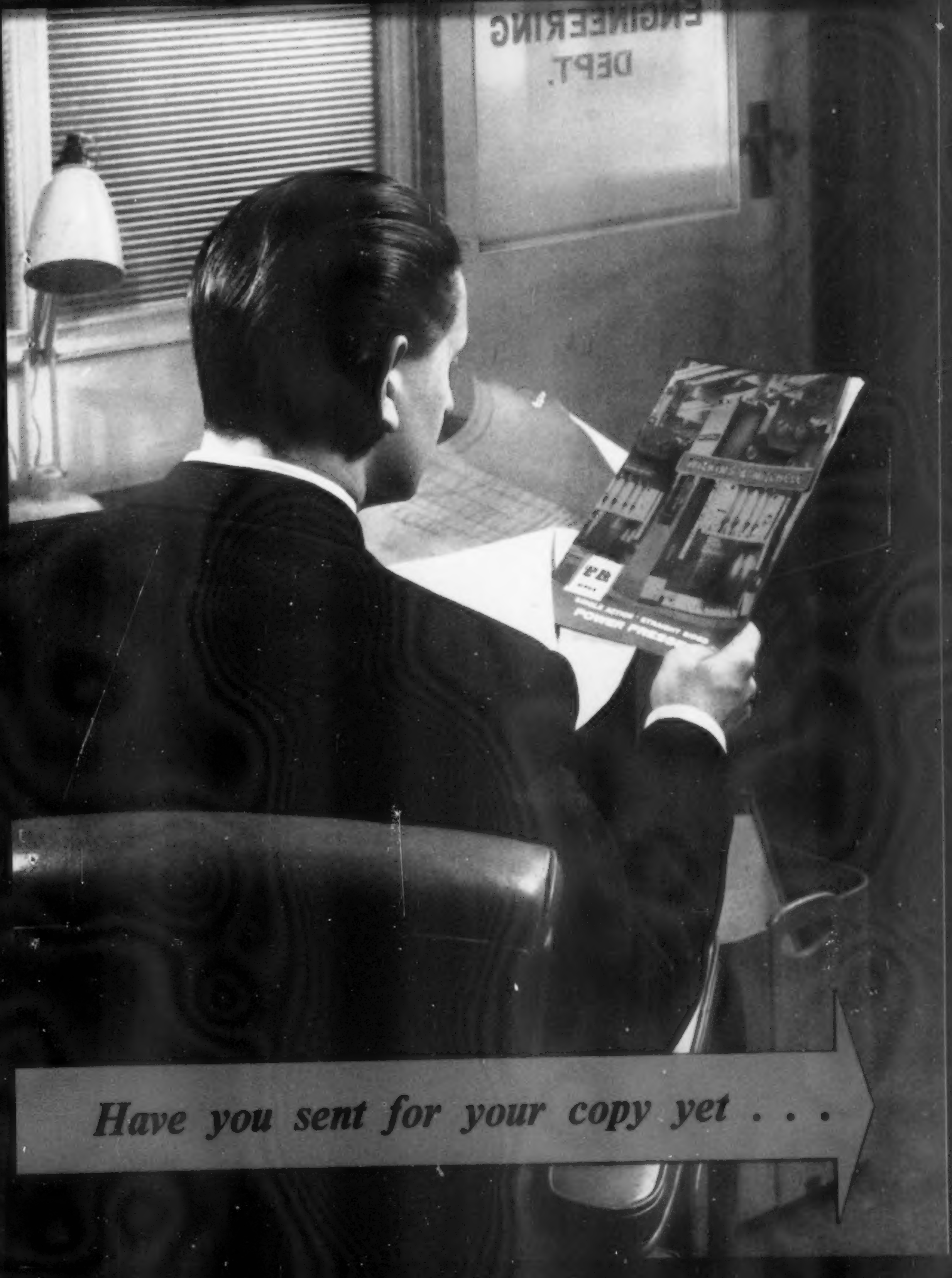
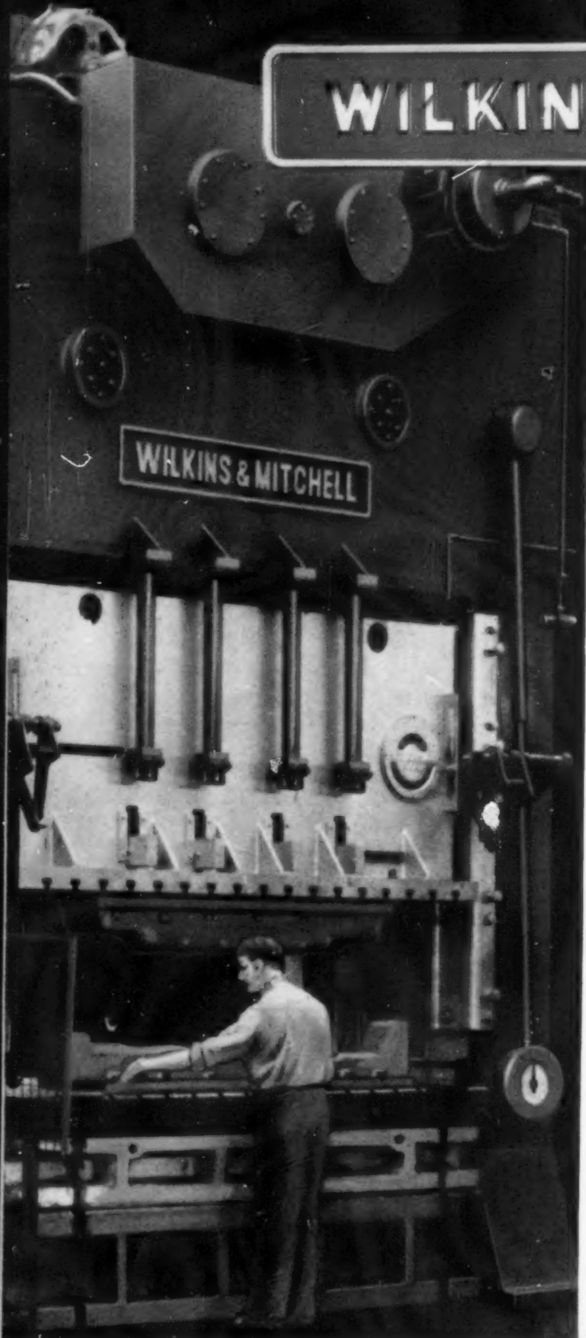

Have you sent for your copy yet . . .

WILKINS & MITCHELL



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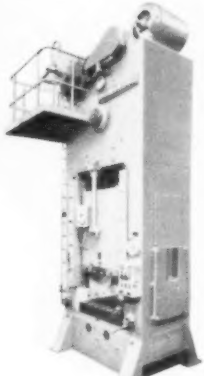
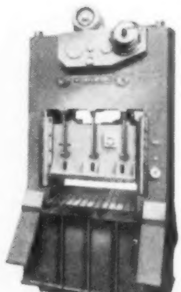


These many features, essential for greater productivity are embodied in this range of Wilkins & Mitchell Power Presses —the presses that cut costs . . .



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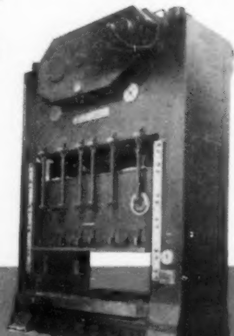

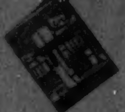

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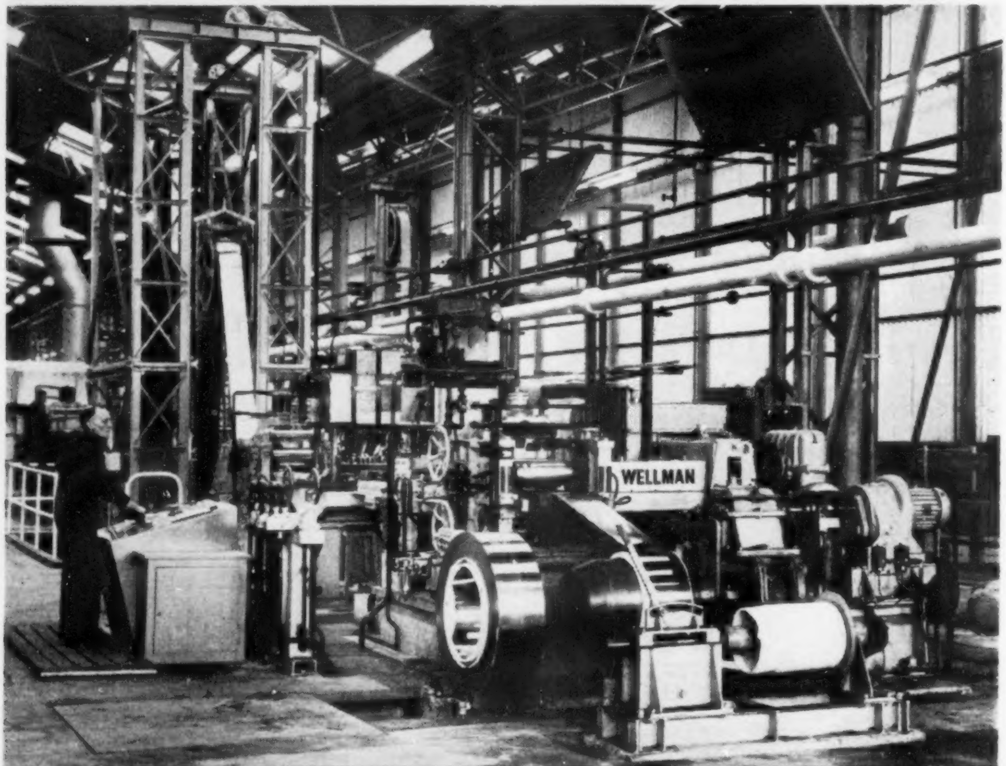

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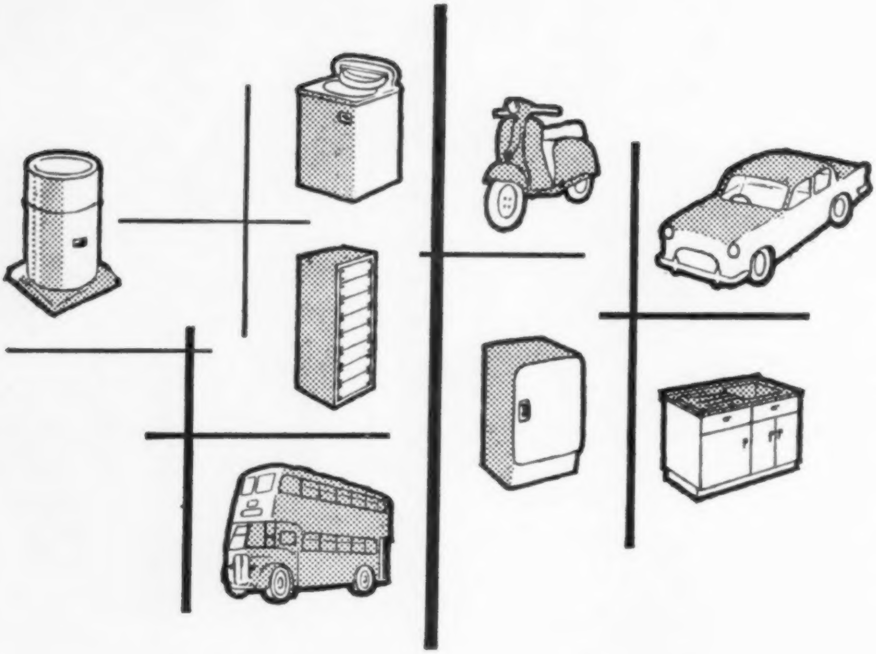

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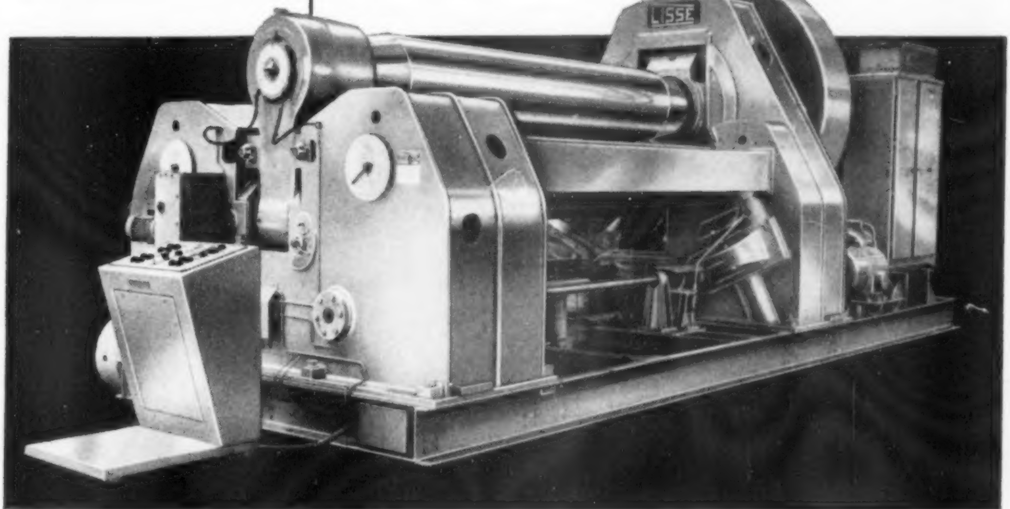

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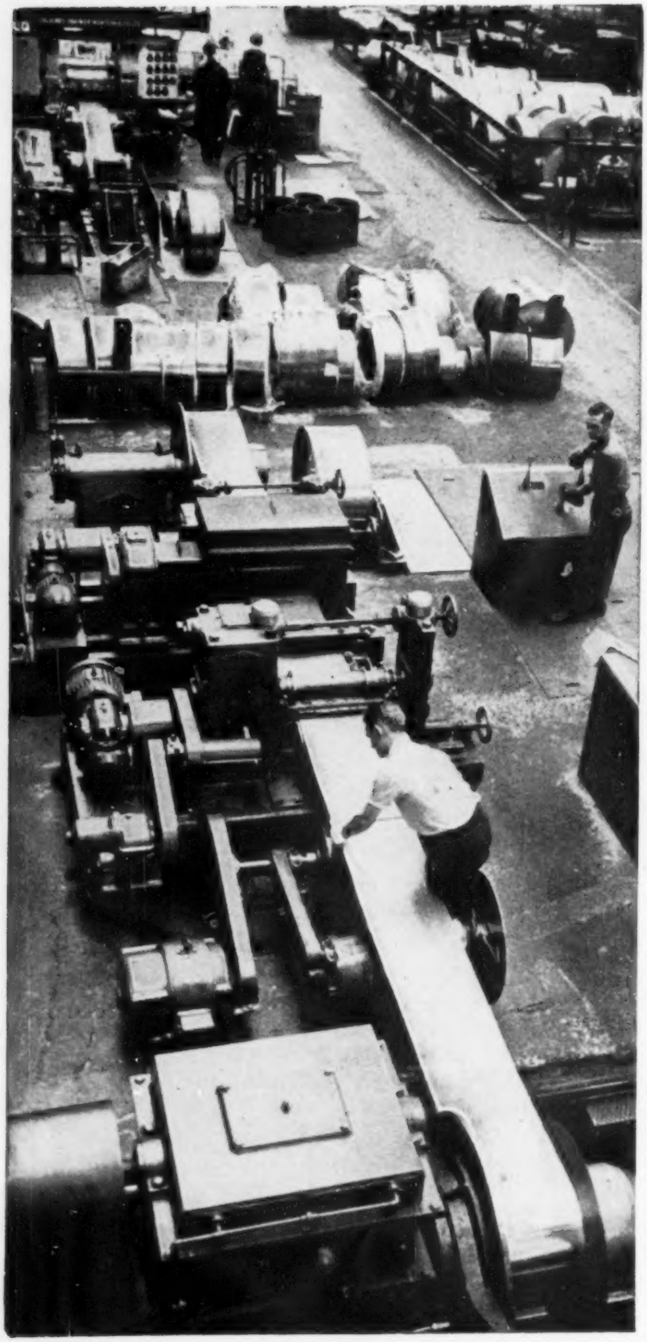

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in FRANCE

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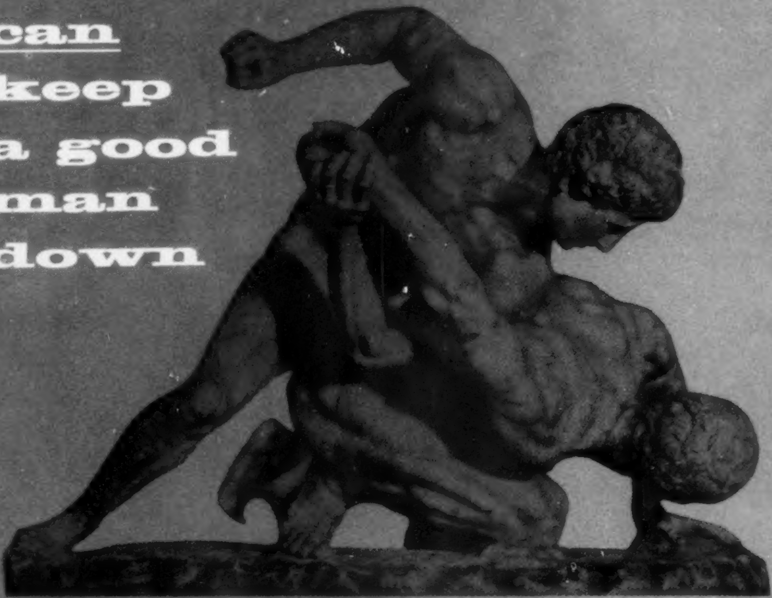

The Wrestlers, Florence, Uffizi.

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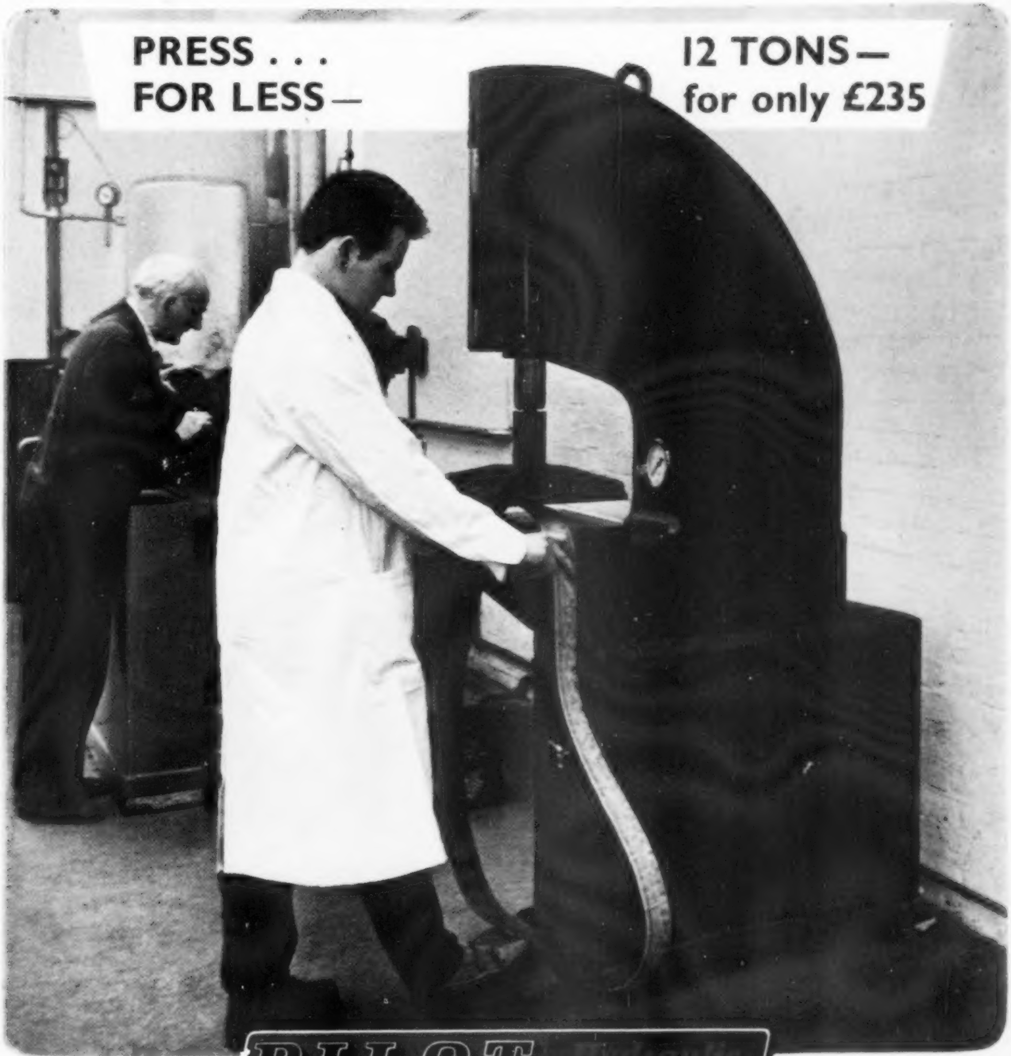

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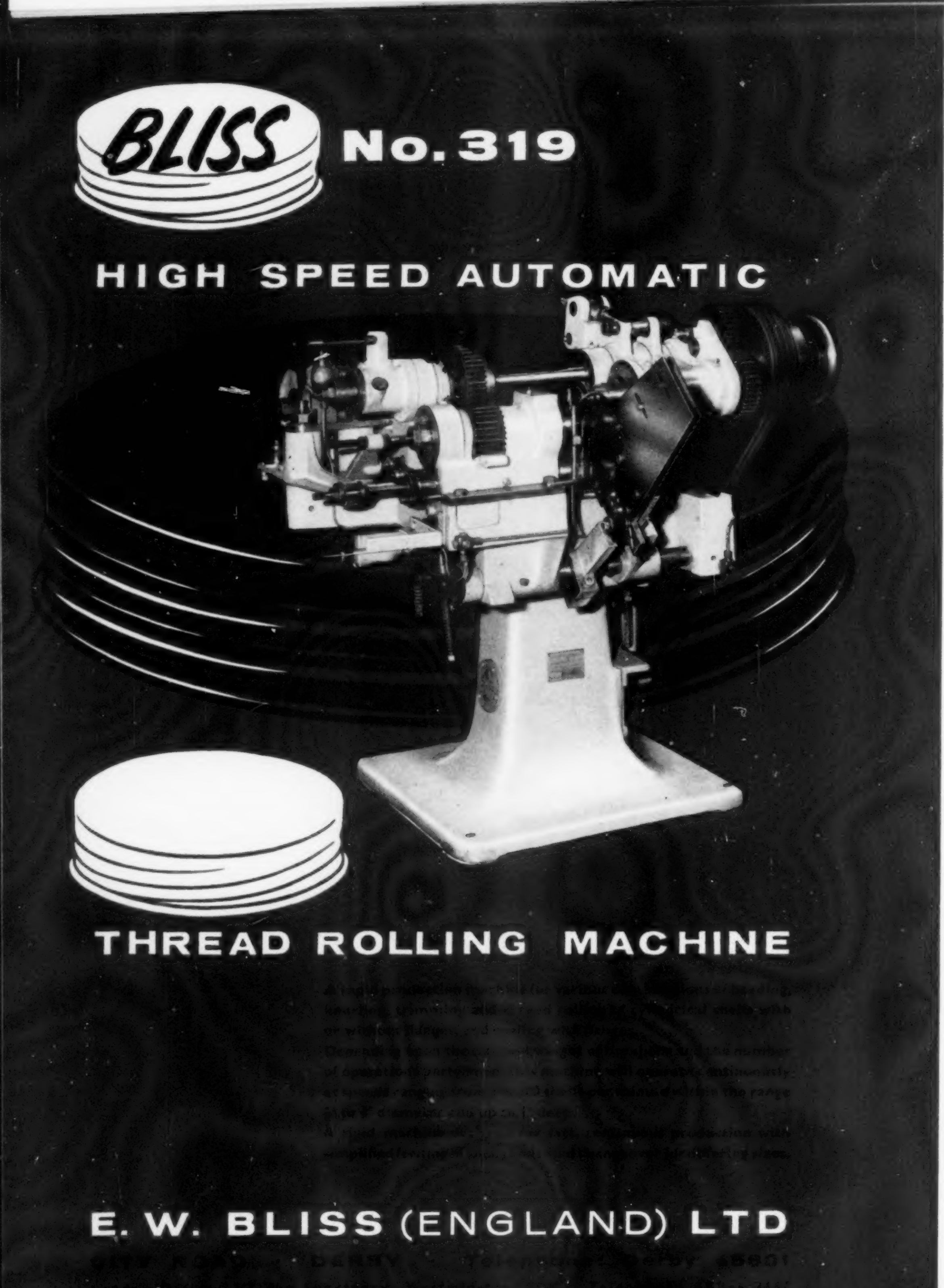
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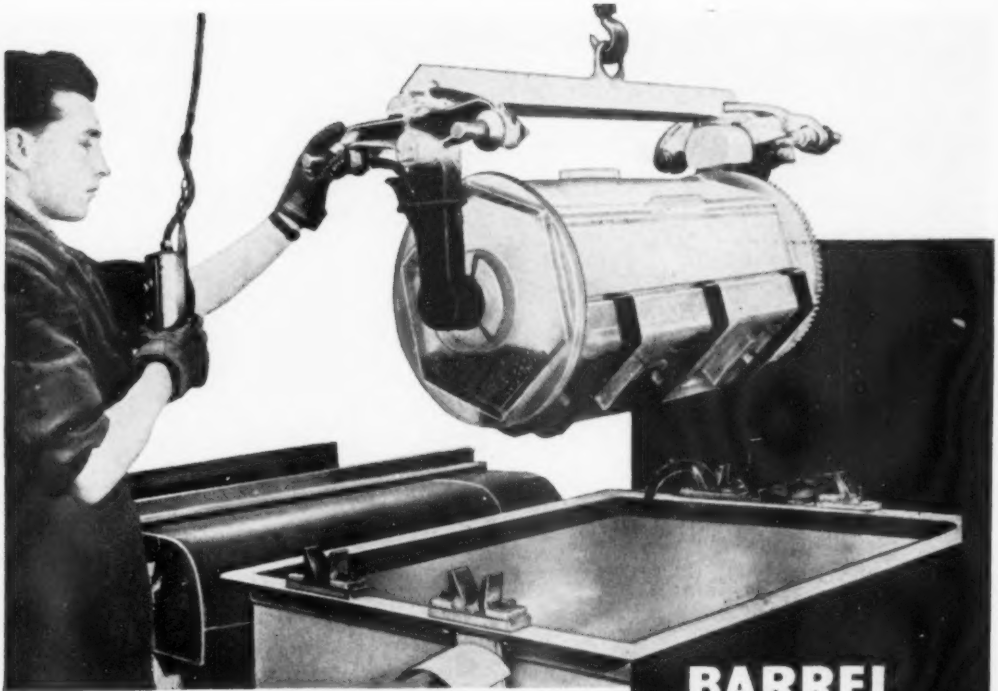

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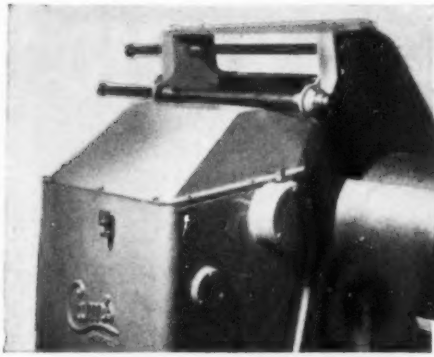

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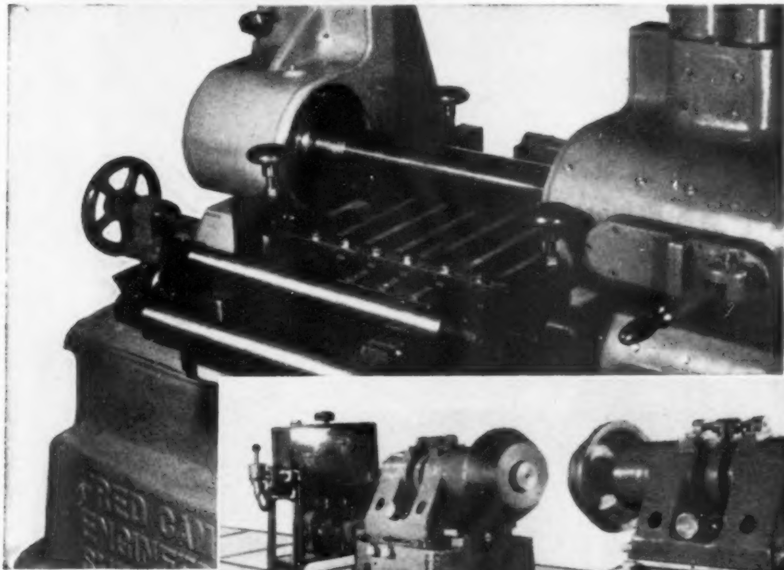

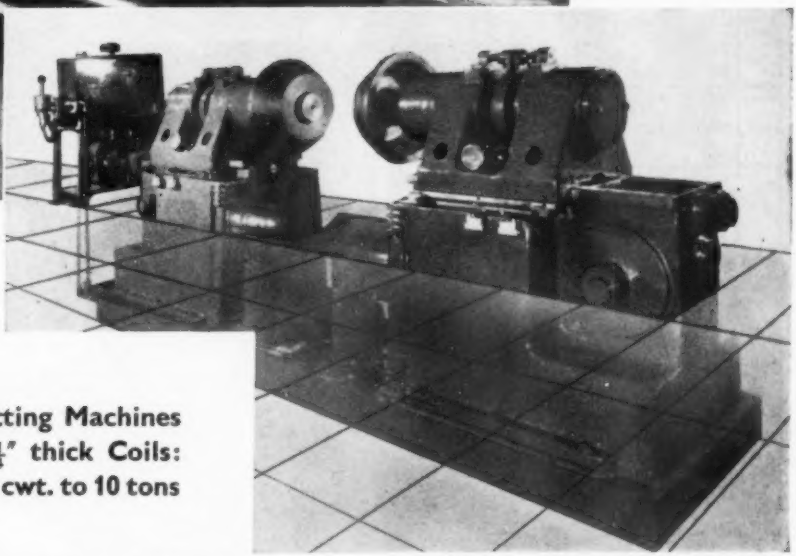

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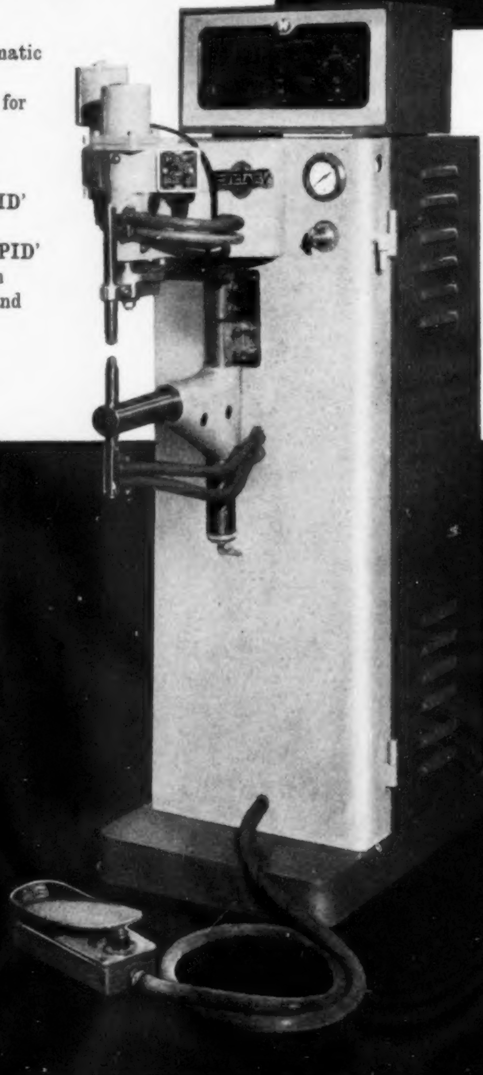

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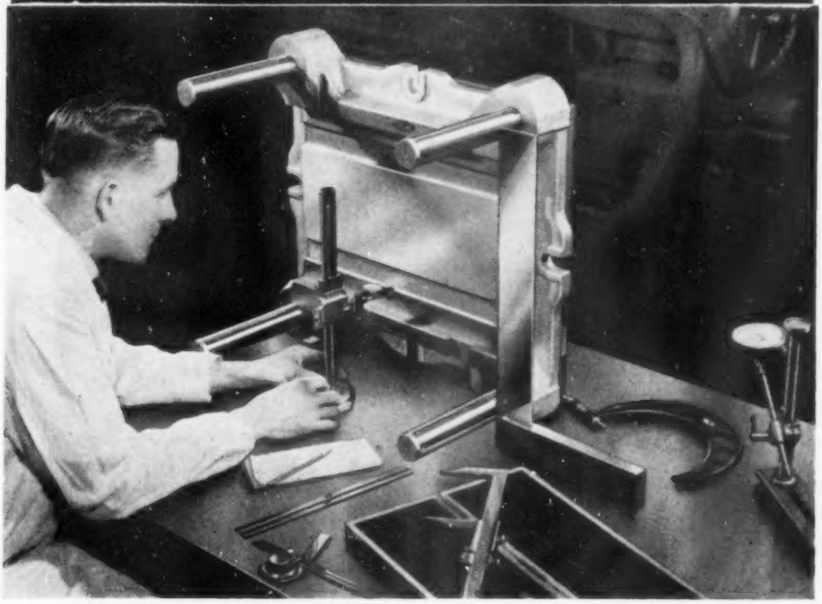

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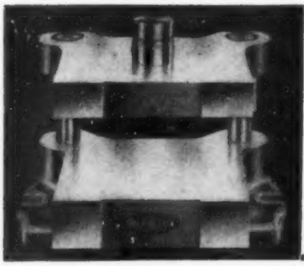

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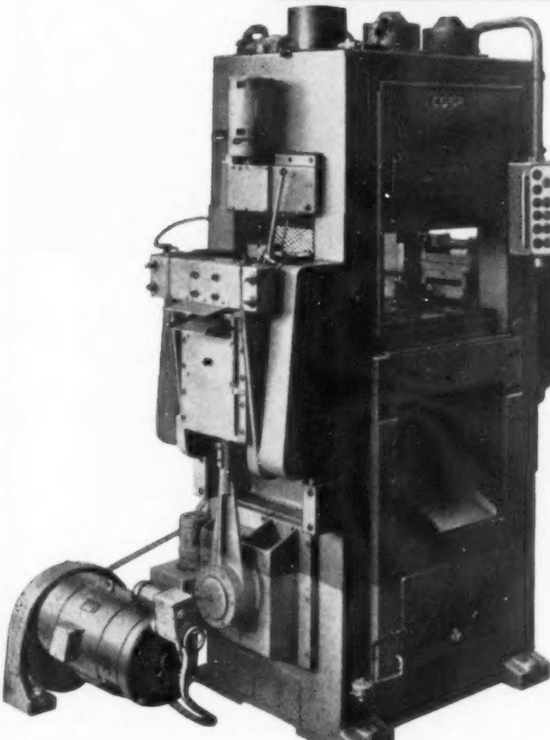

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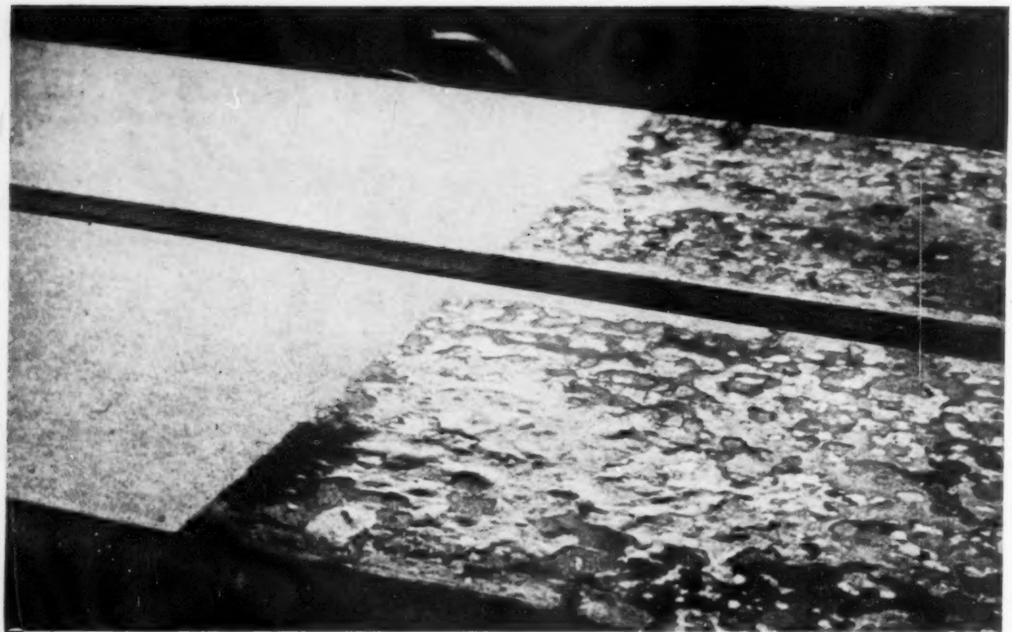

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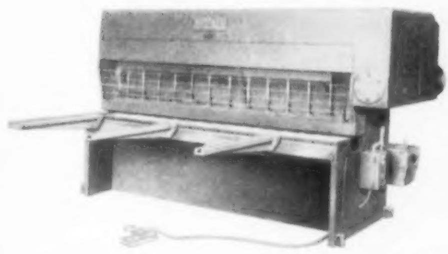

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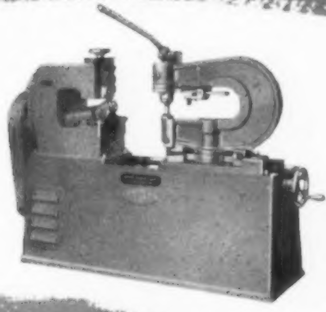

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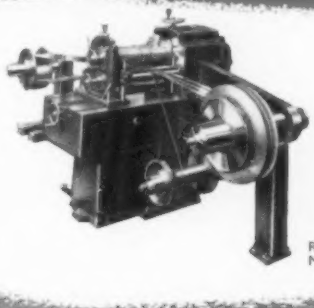

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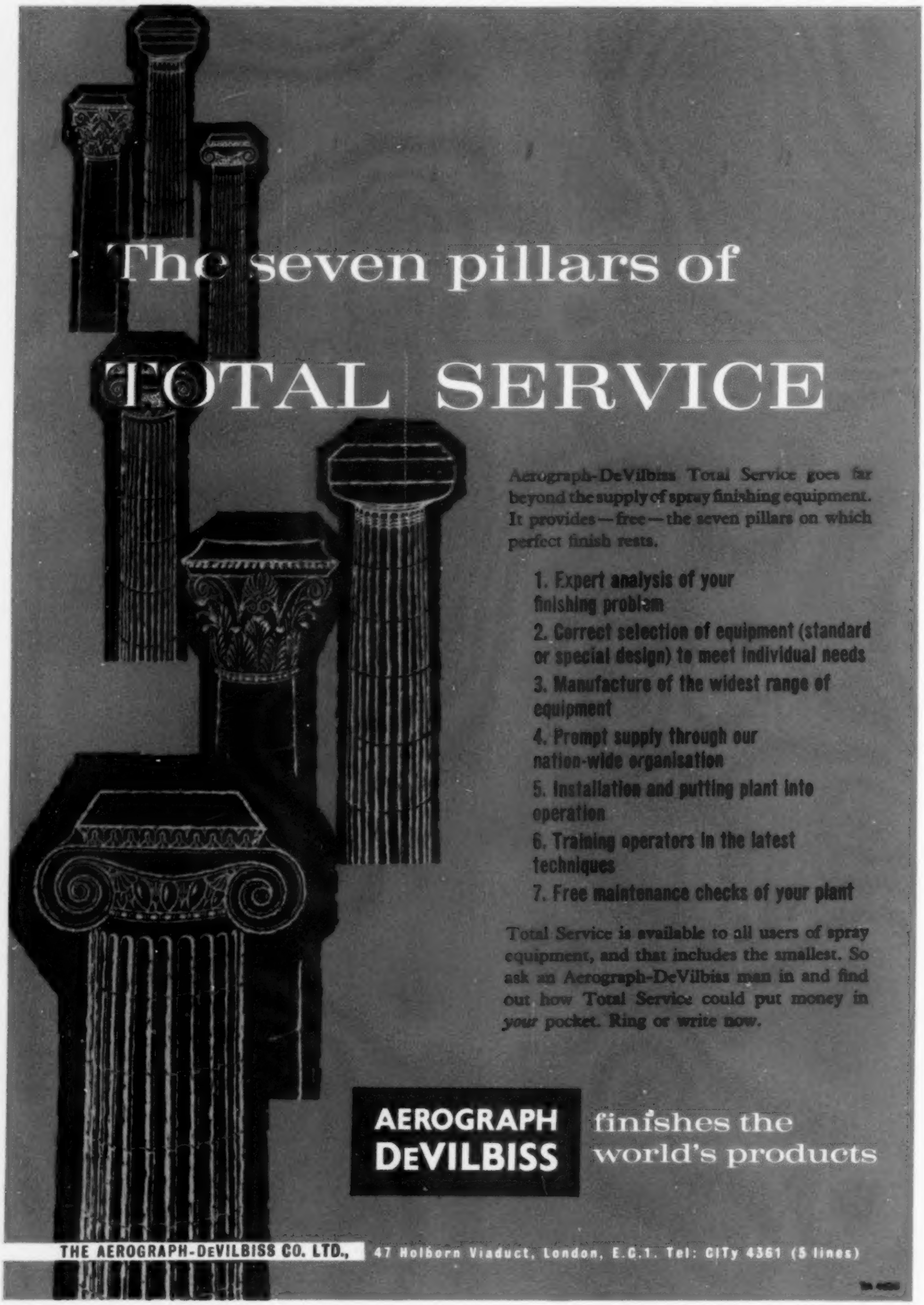
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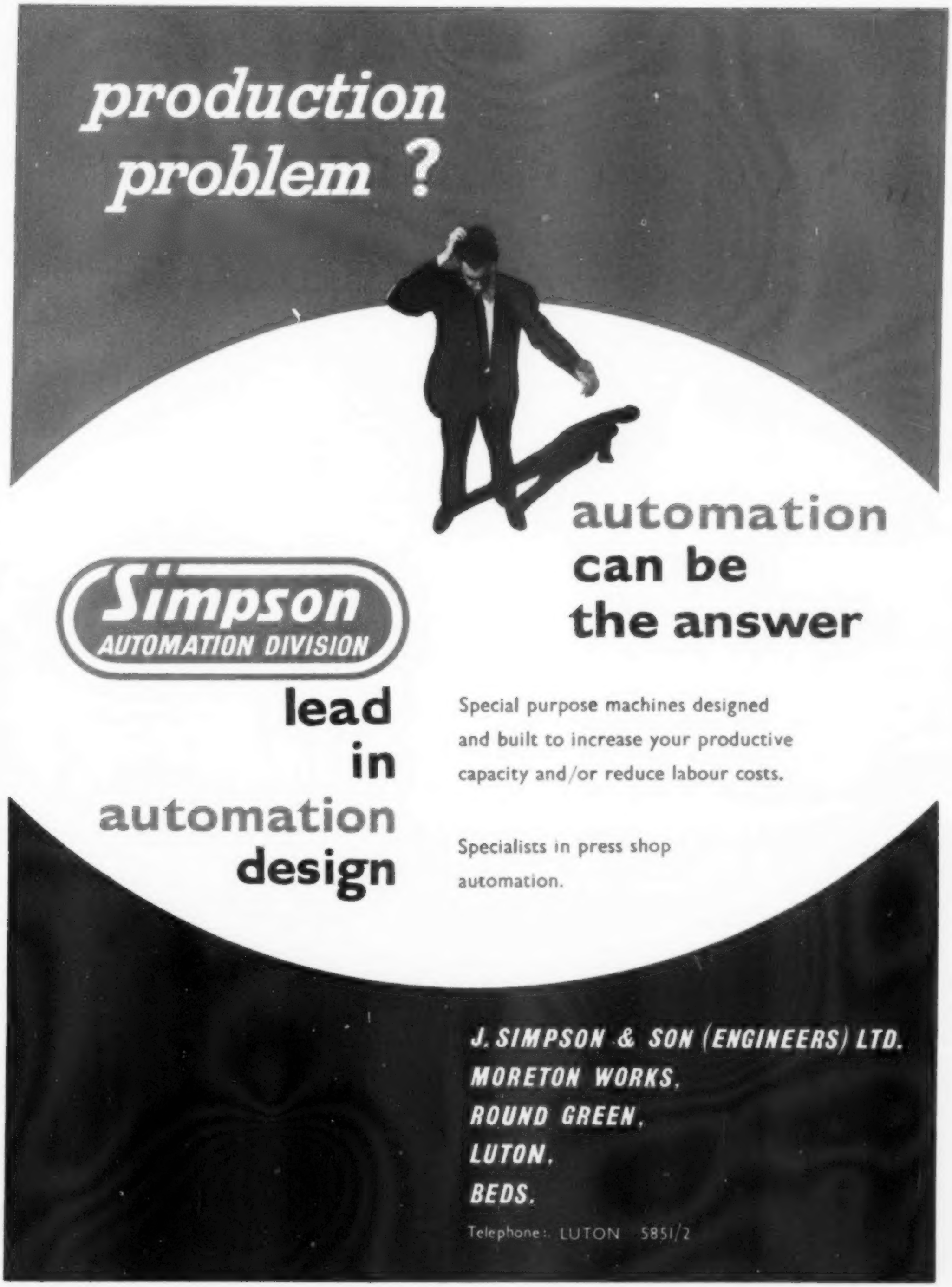
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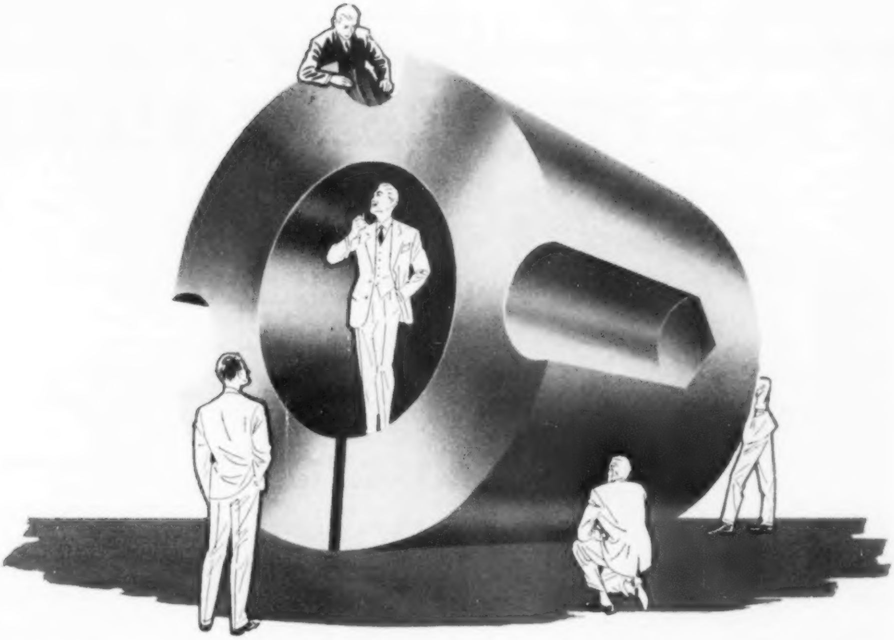

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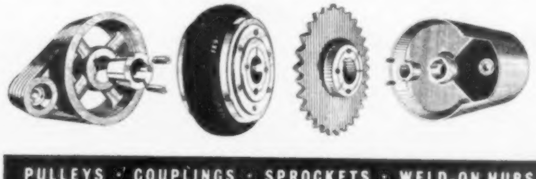

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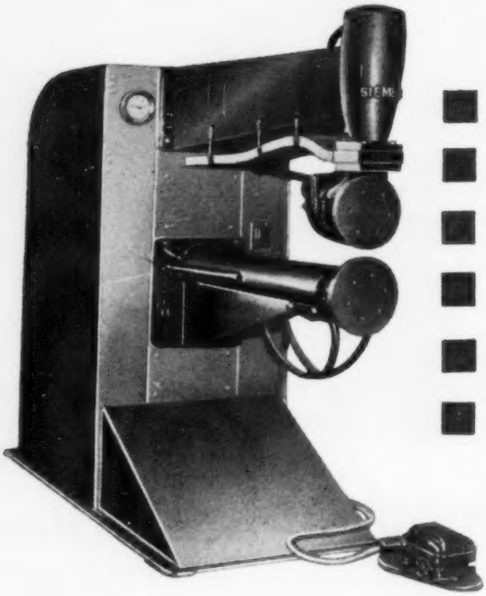

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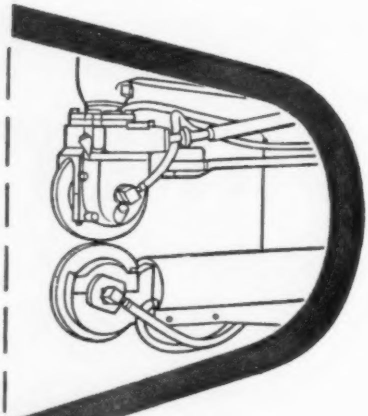

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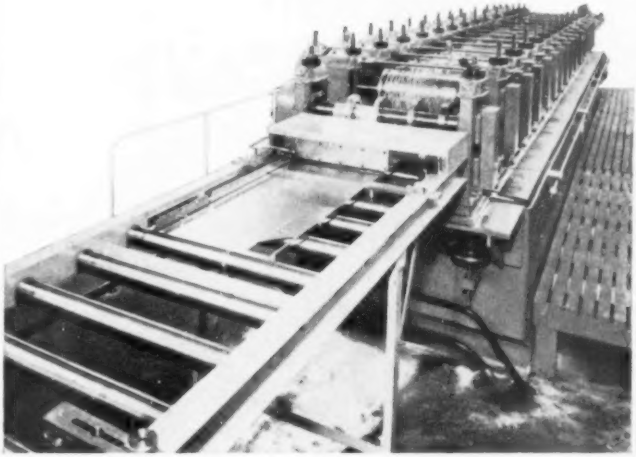

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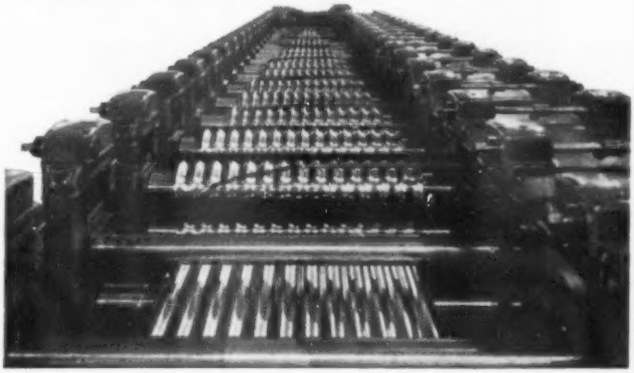

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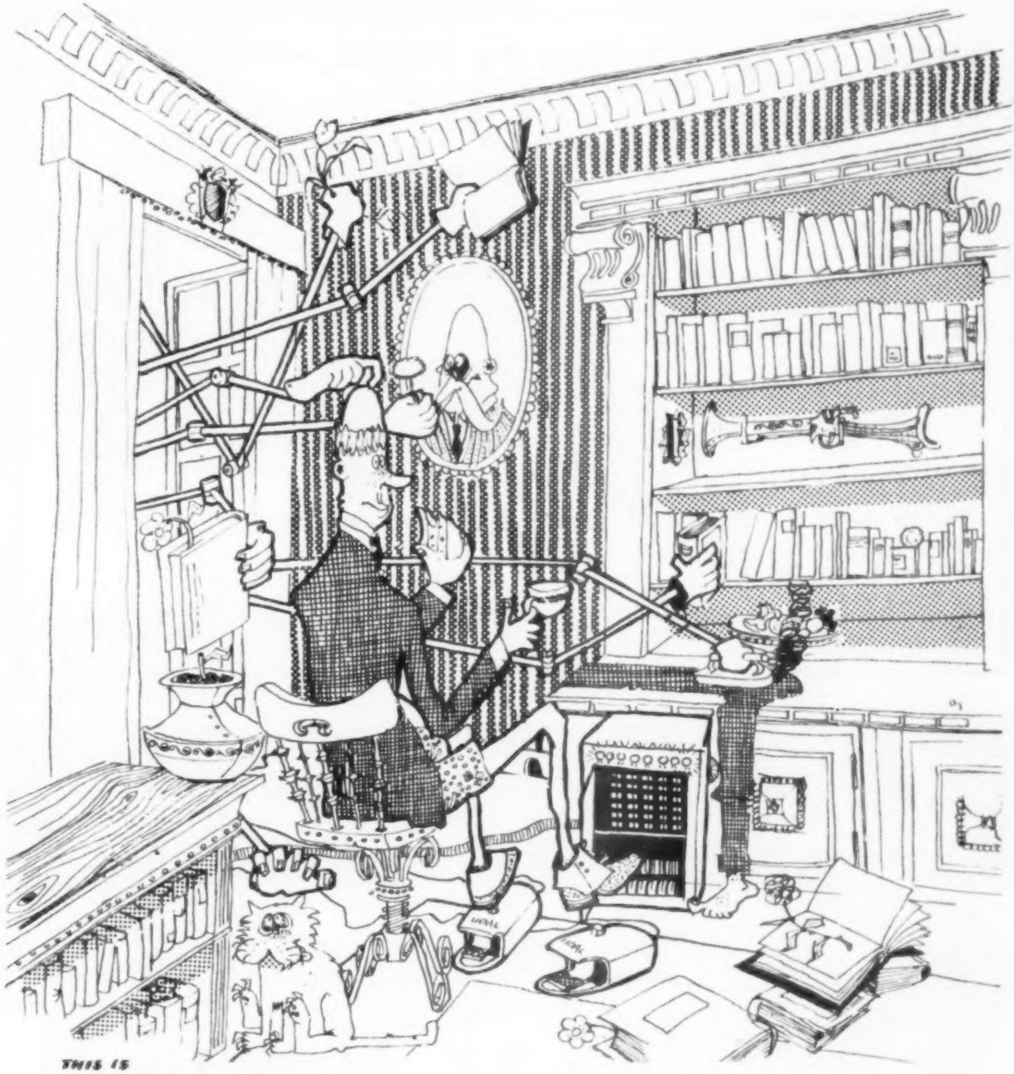

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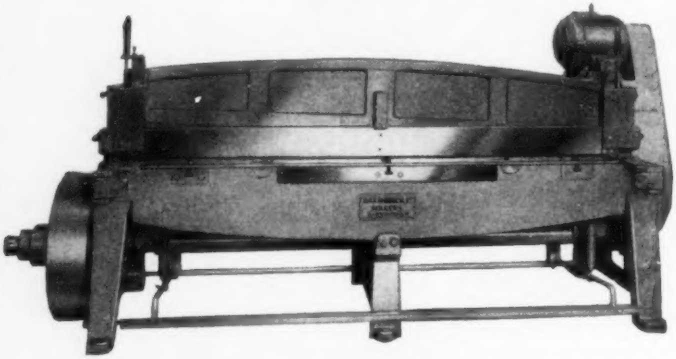

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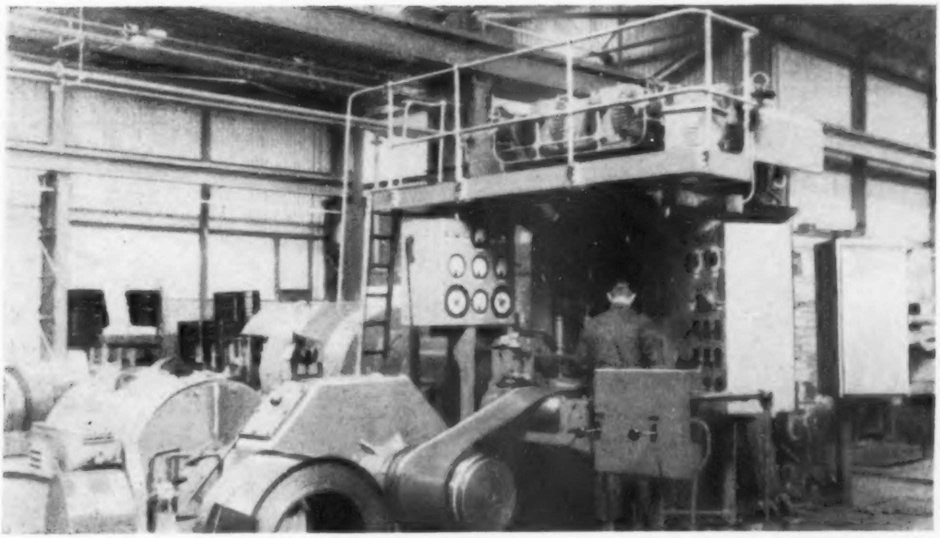

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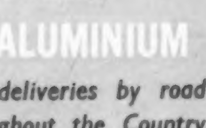

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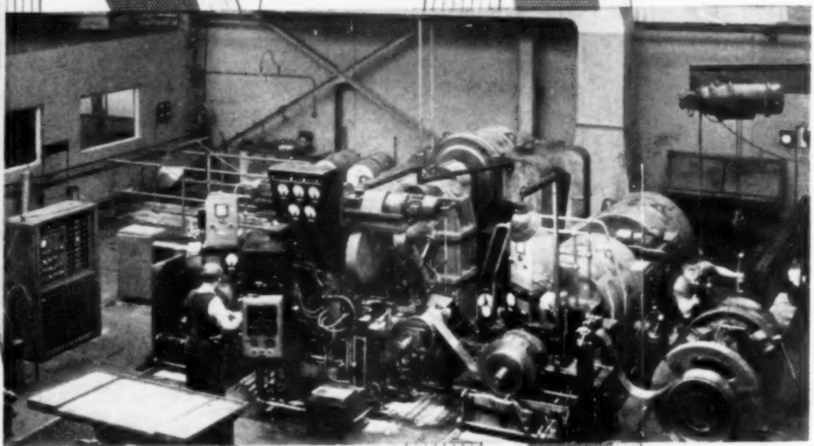

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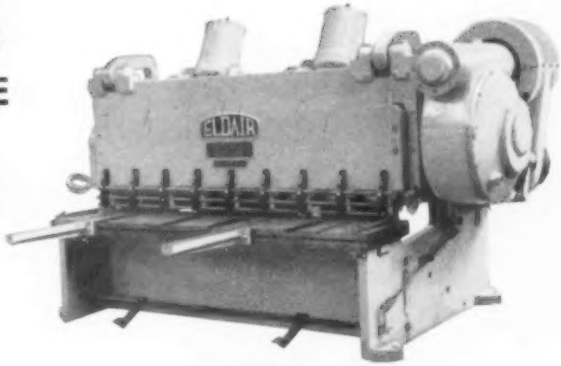

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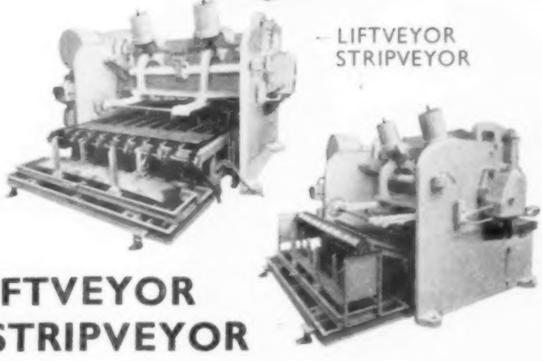

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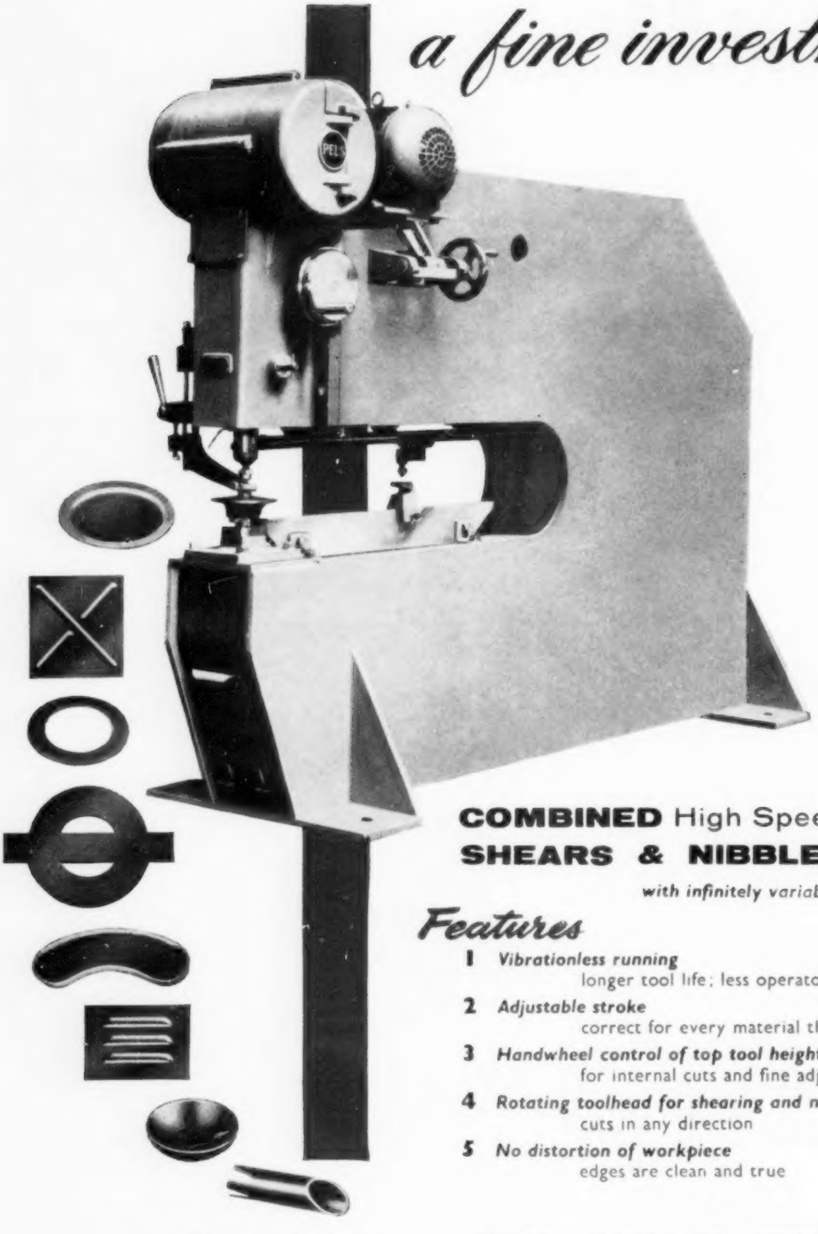

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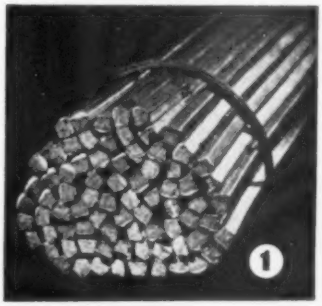

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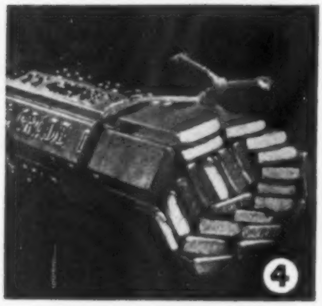

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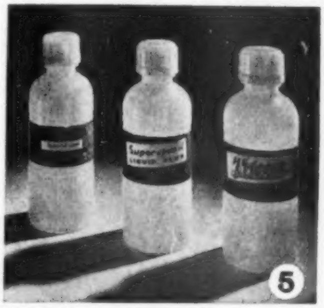

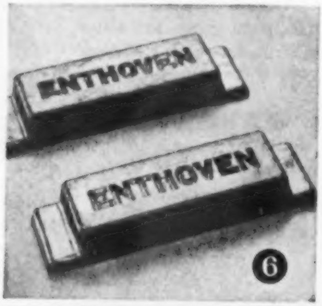

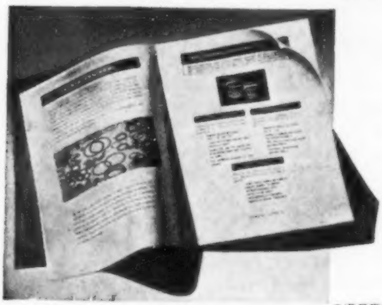

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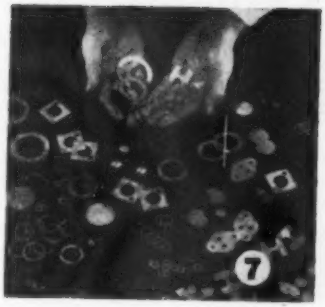

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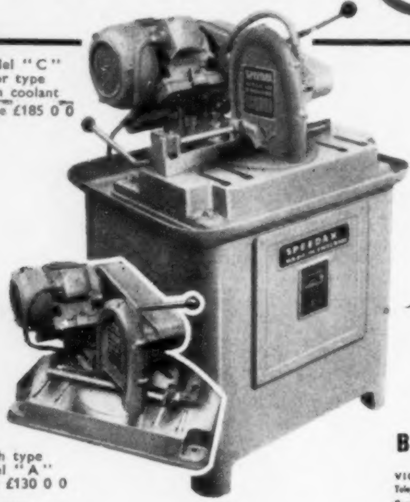

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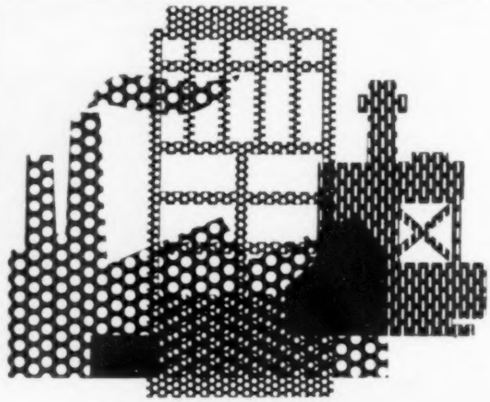

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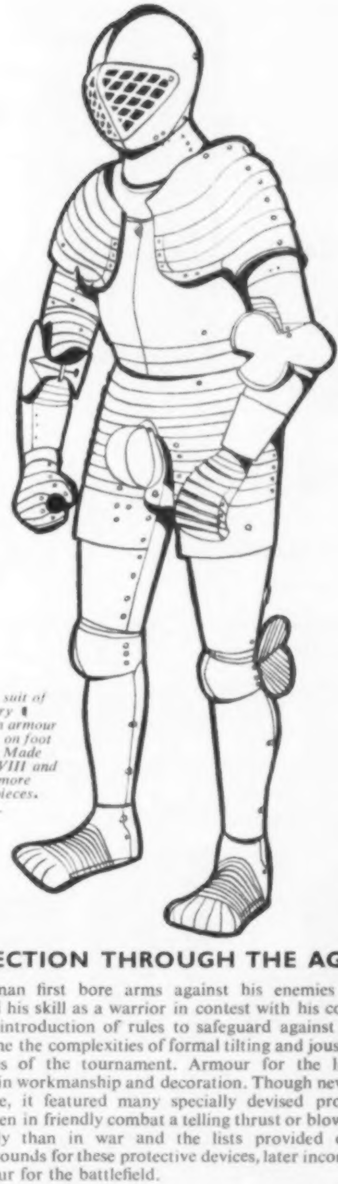

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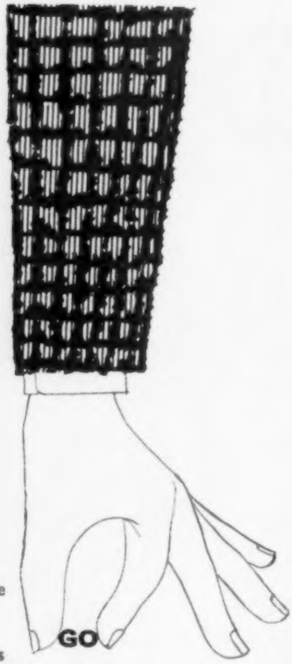

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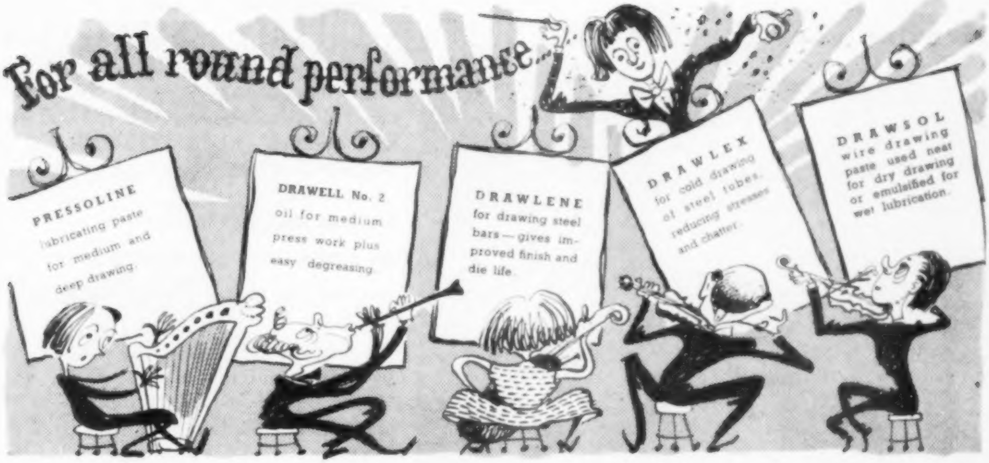

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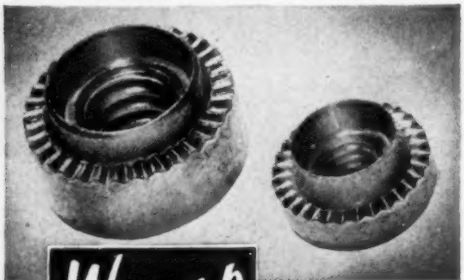

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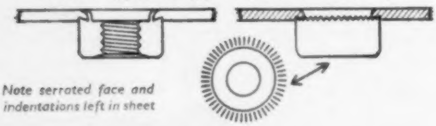

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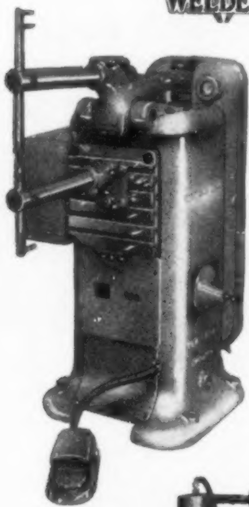

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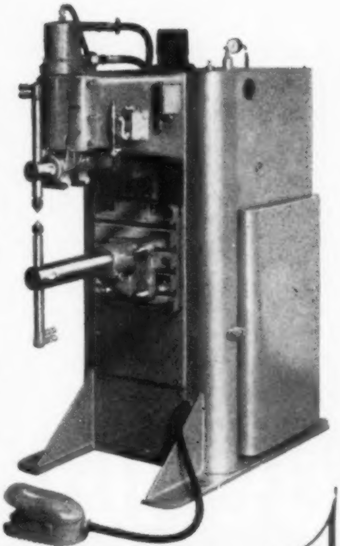

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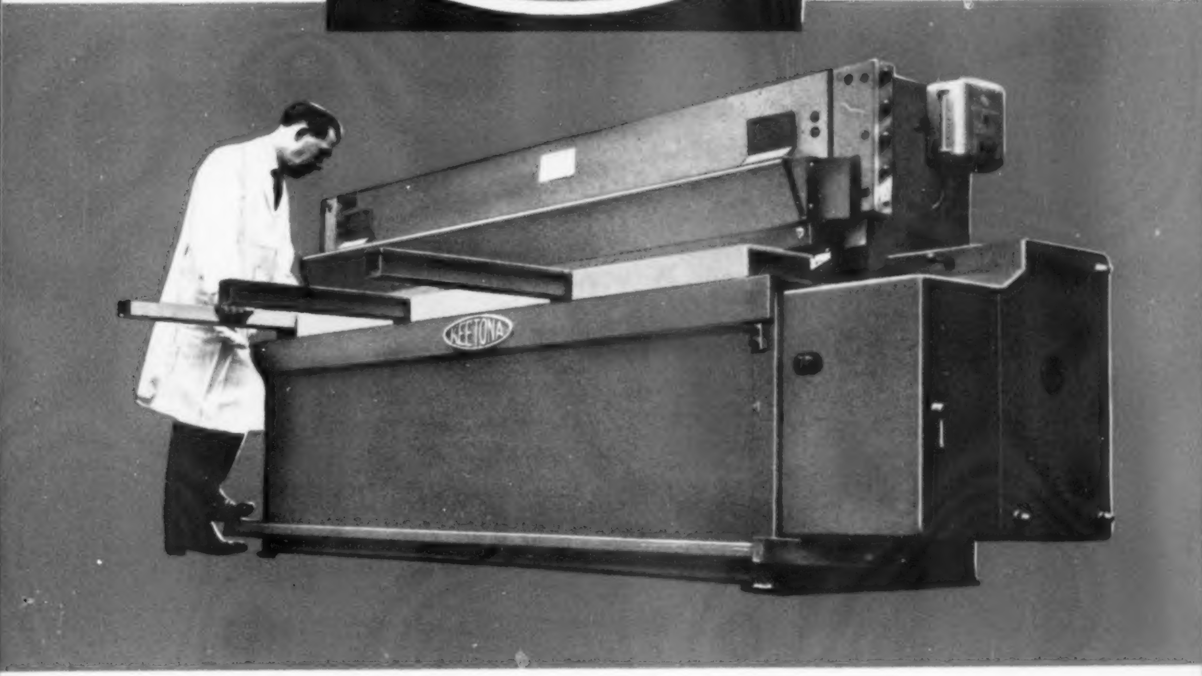

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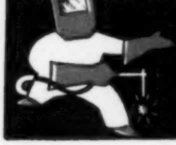

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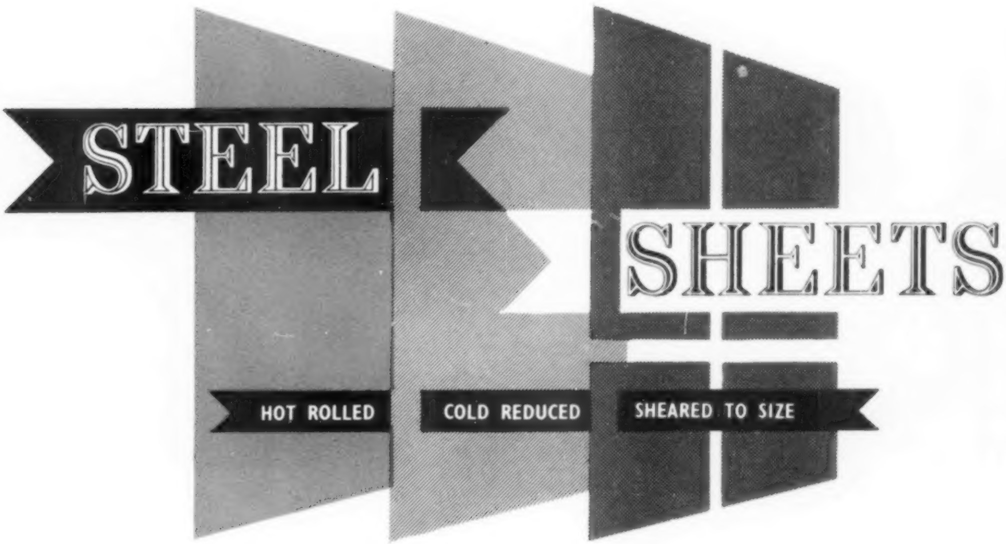

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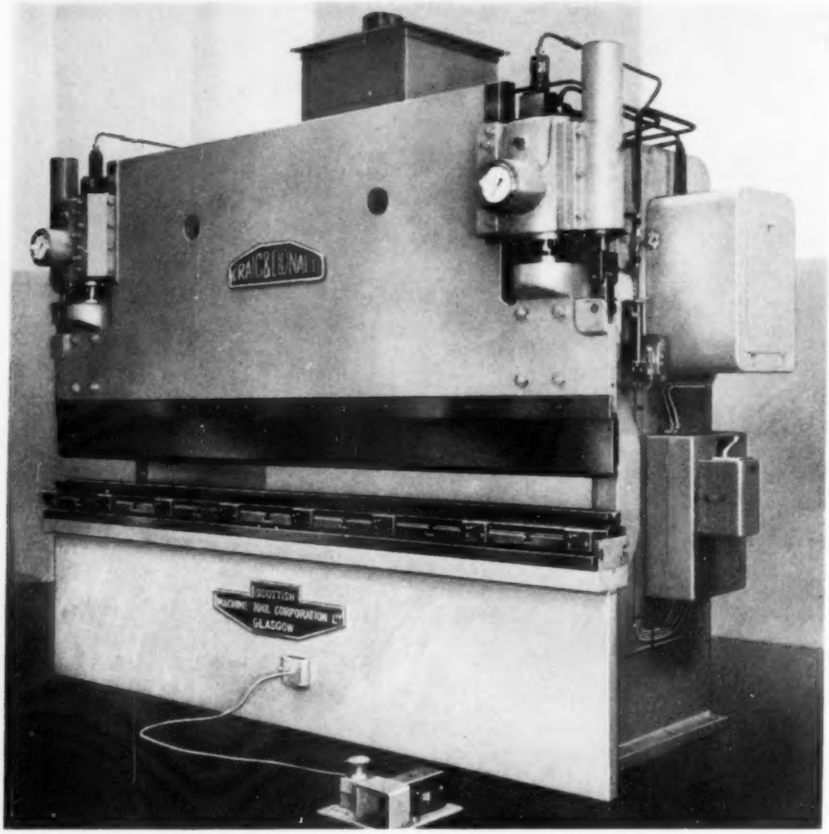

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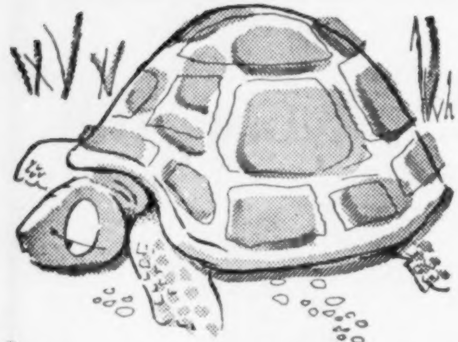

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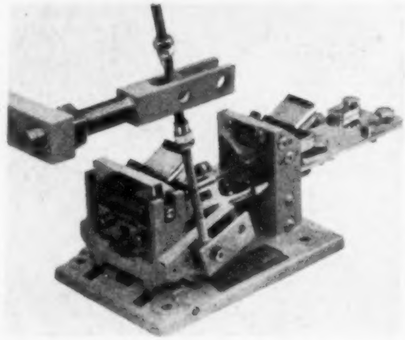

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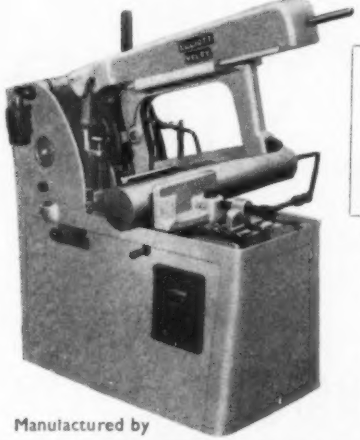

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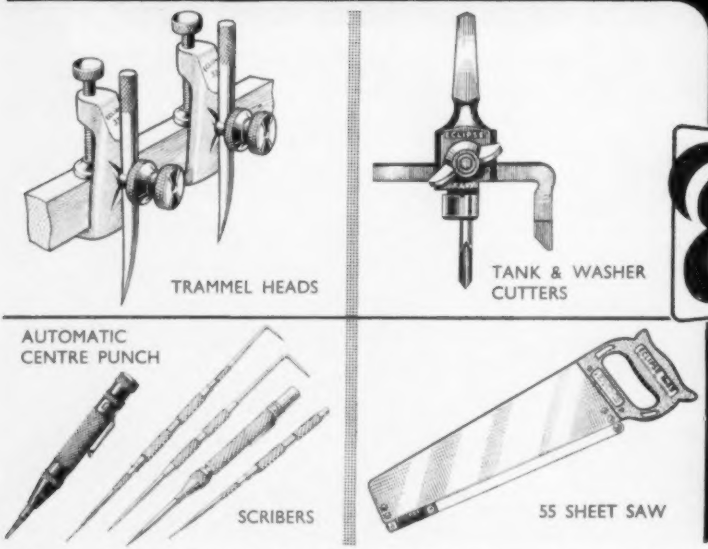

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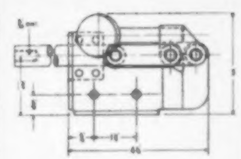
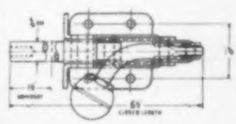
Patent No. 749367

This is the first Clamp designed to carry out both "push" clamping and "pull" clamping without adjustments or re-fitting to the clamp itself. No nuts, bolts or split pins to remove for this dual-purpose clamping.



Closed position for "push" clamping. Neat and compact.



Plan view of above. Reverse position for "pull" clamping.

FULL LITERATURE SUPPLIED

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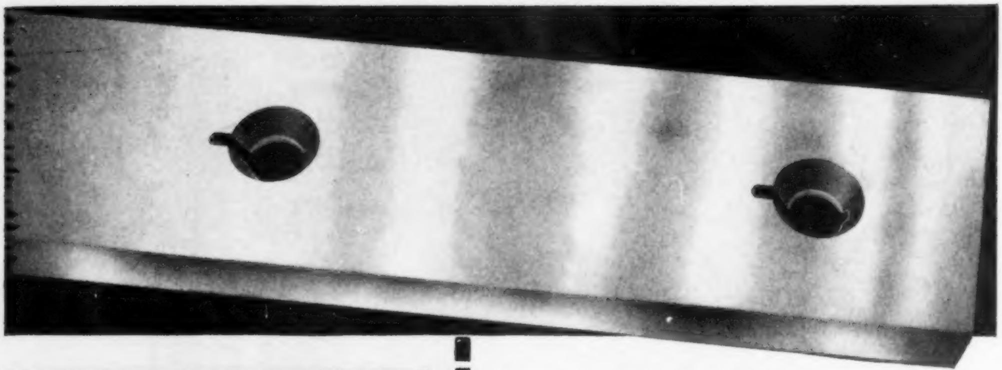

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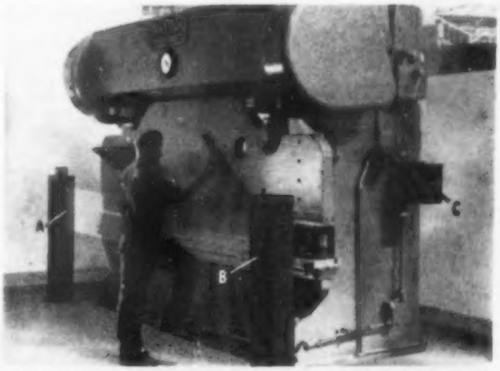

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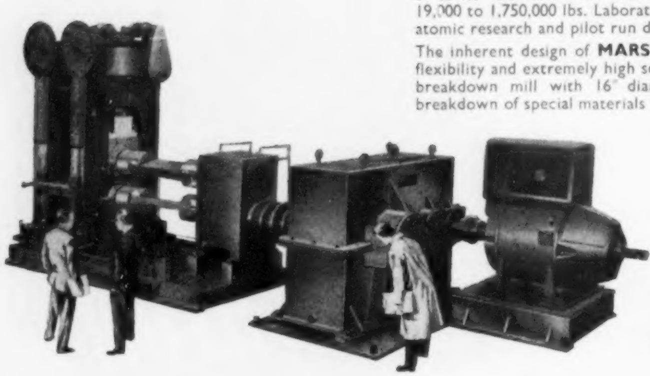

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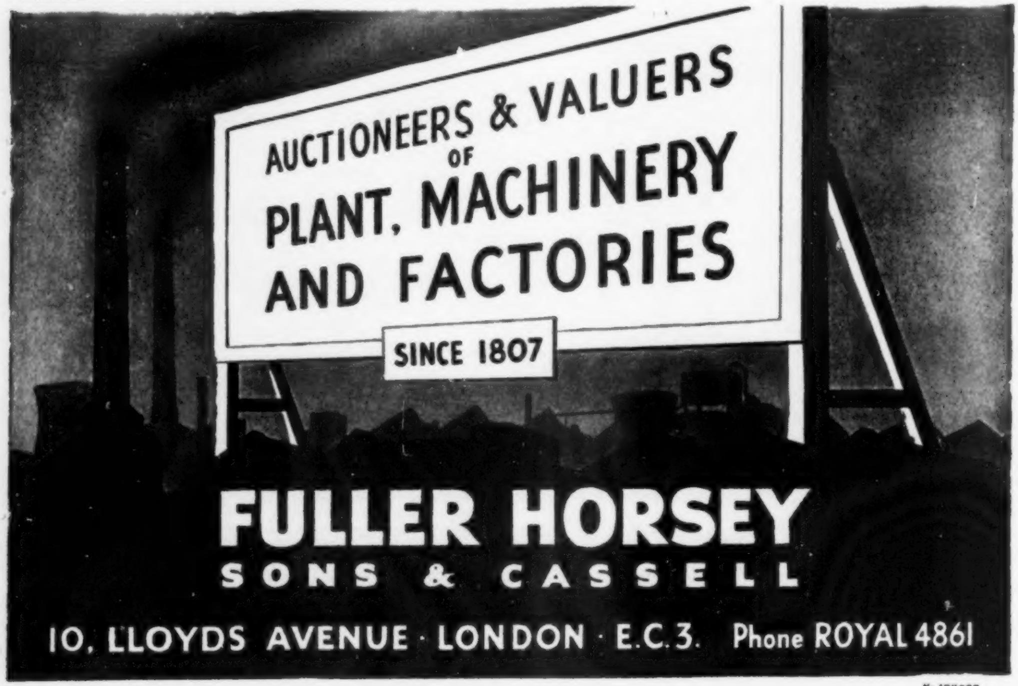

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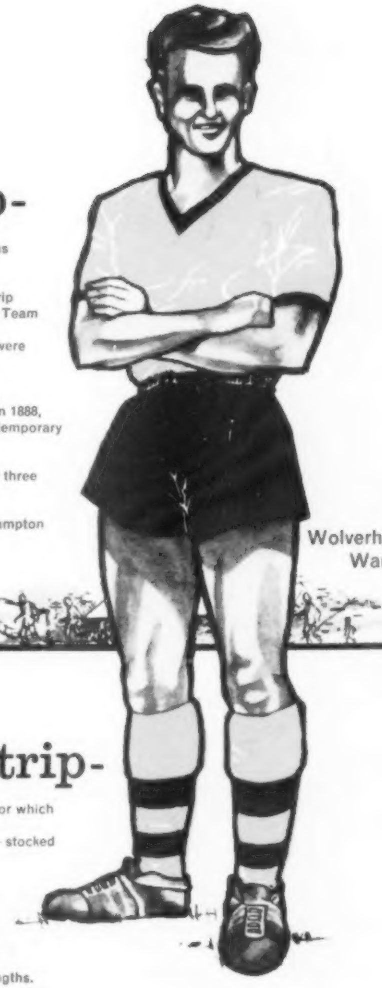

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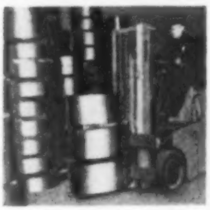

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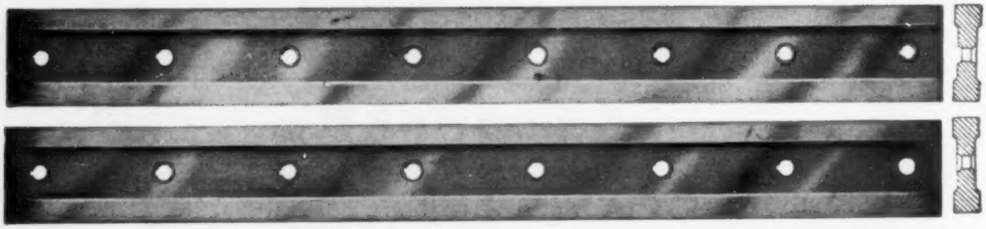

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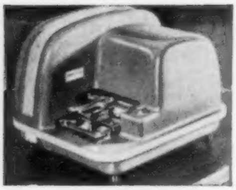
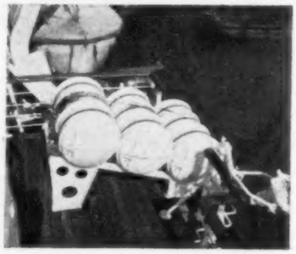


all-round successes with Cellobond polyester resins



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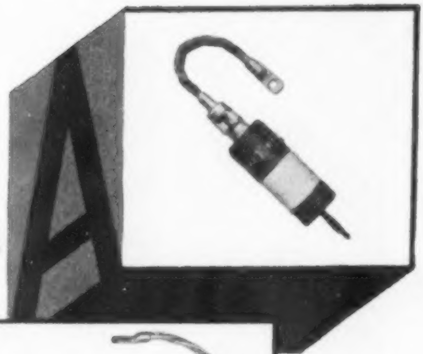

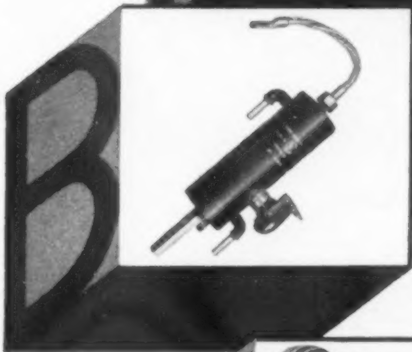

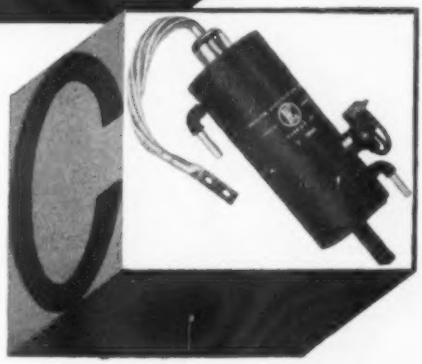

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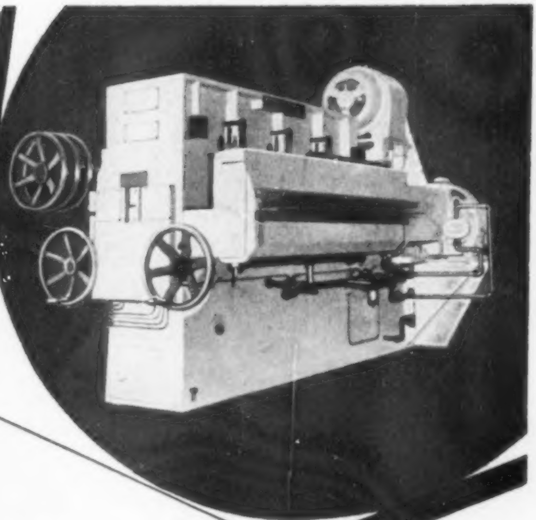
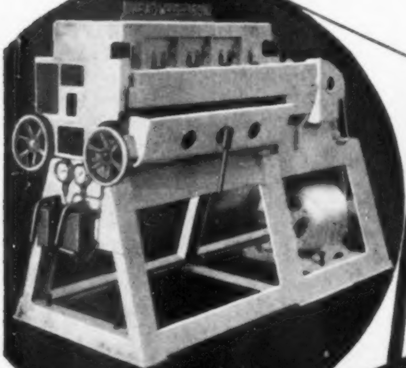
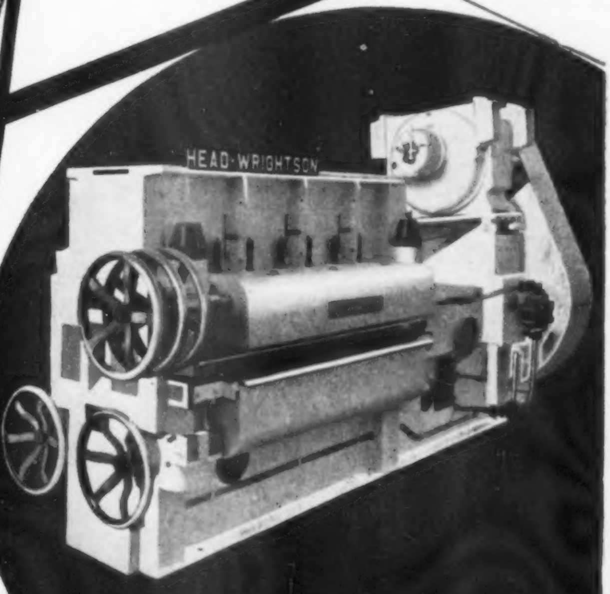


Left: 1⅛" Pressure Regulating Roller Leveller



Top: 1¾" Processor Leveller

Bottom: 2½" Pressure Regulating Roller Leveller



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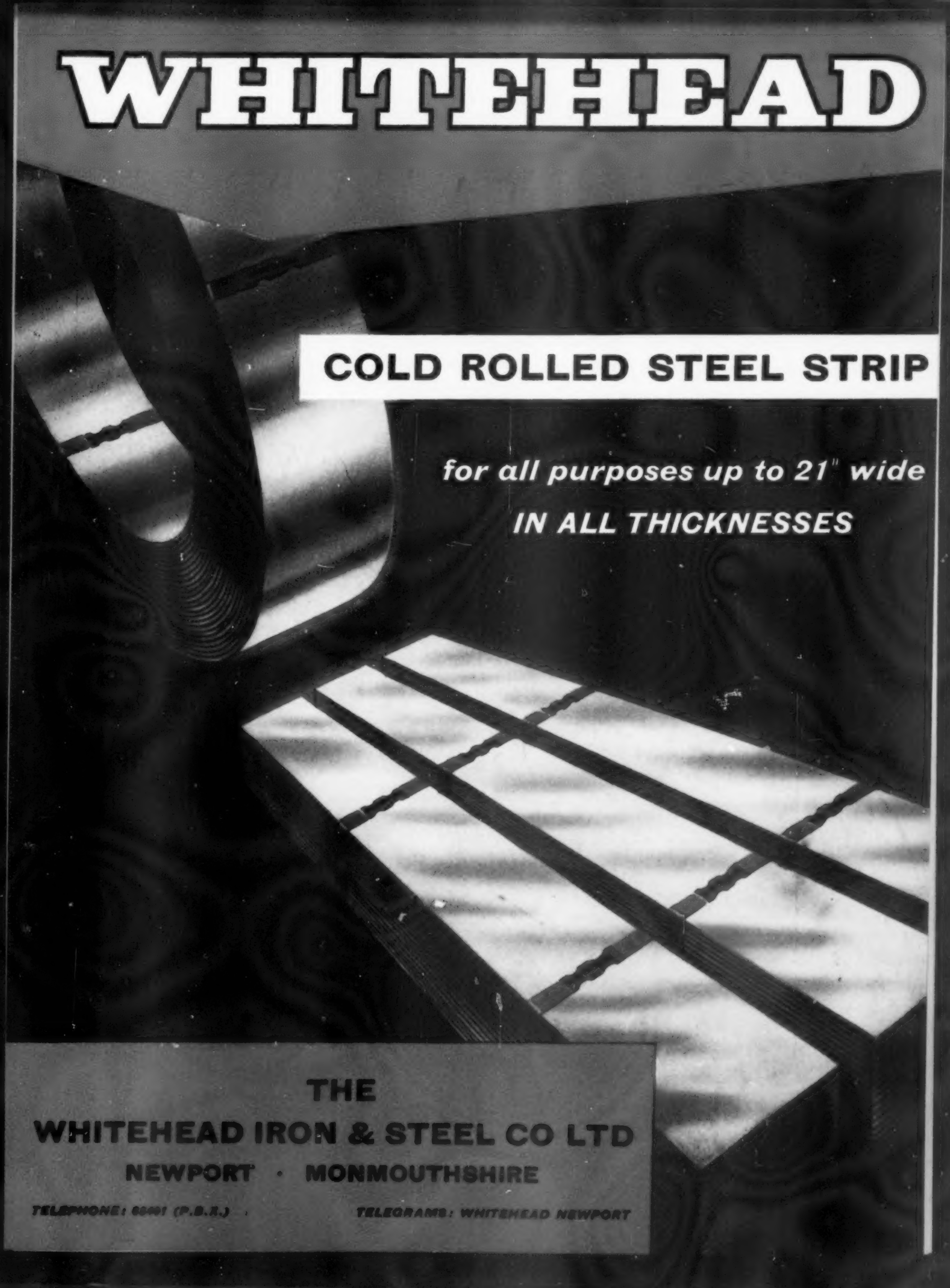
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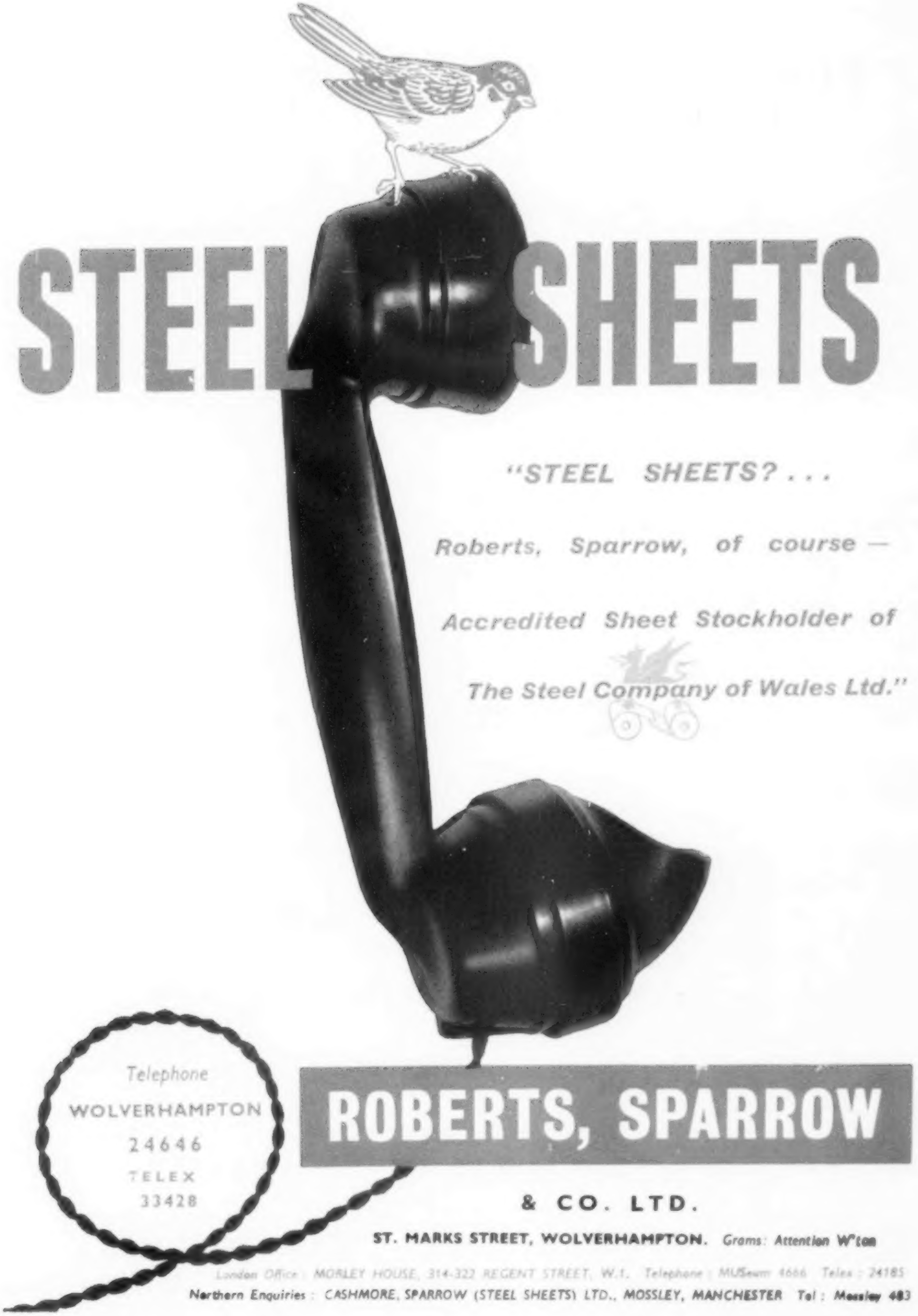
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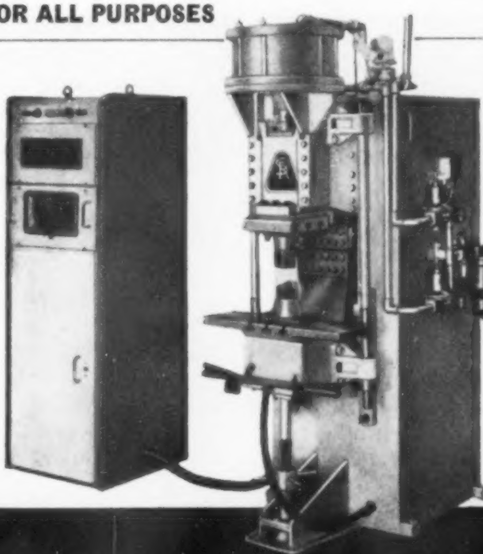

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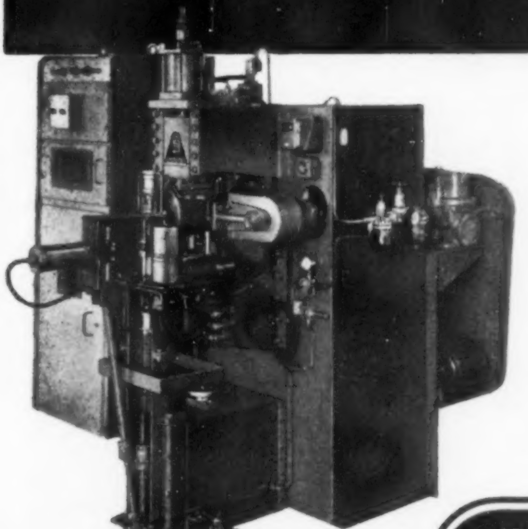

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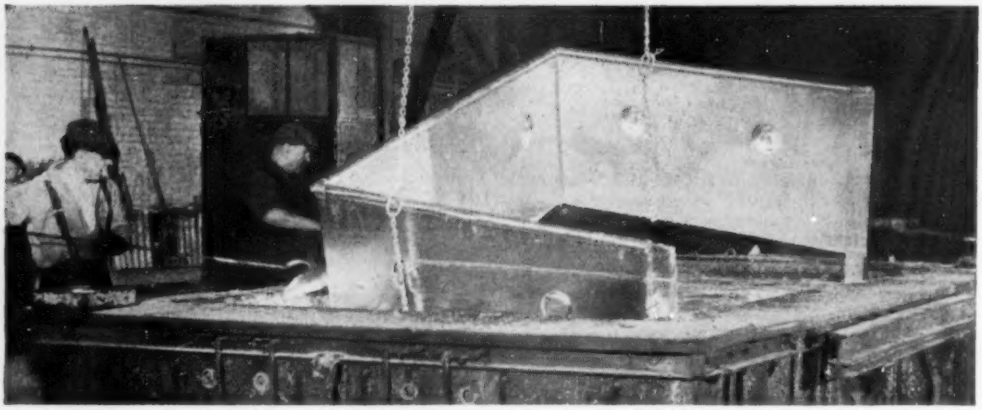

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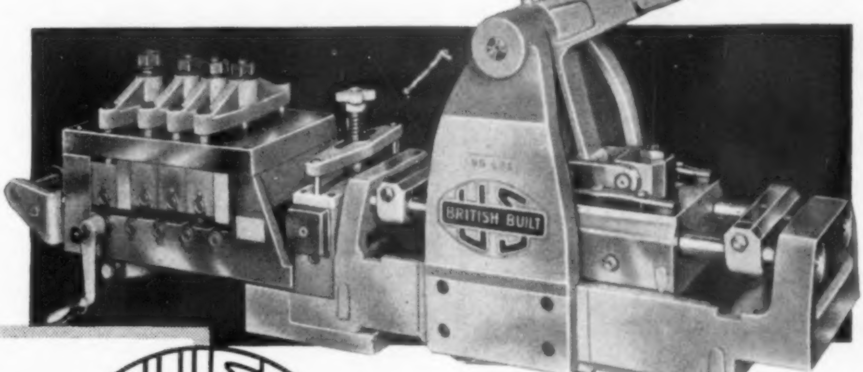

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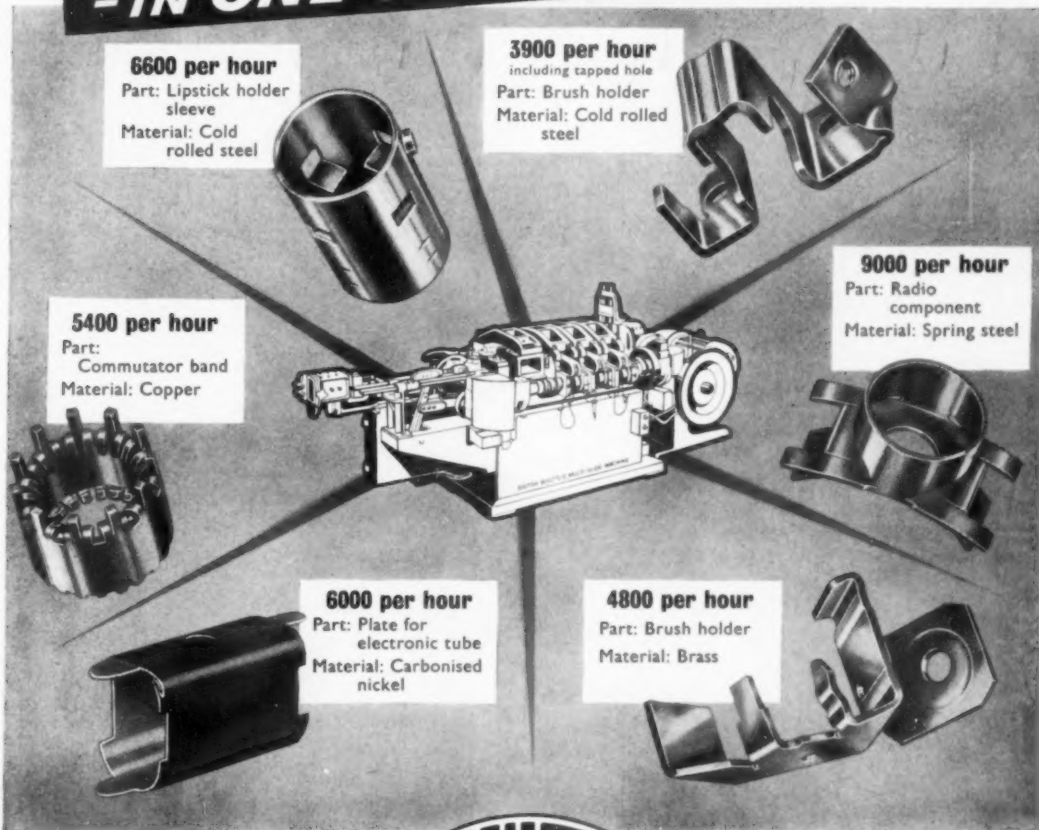

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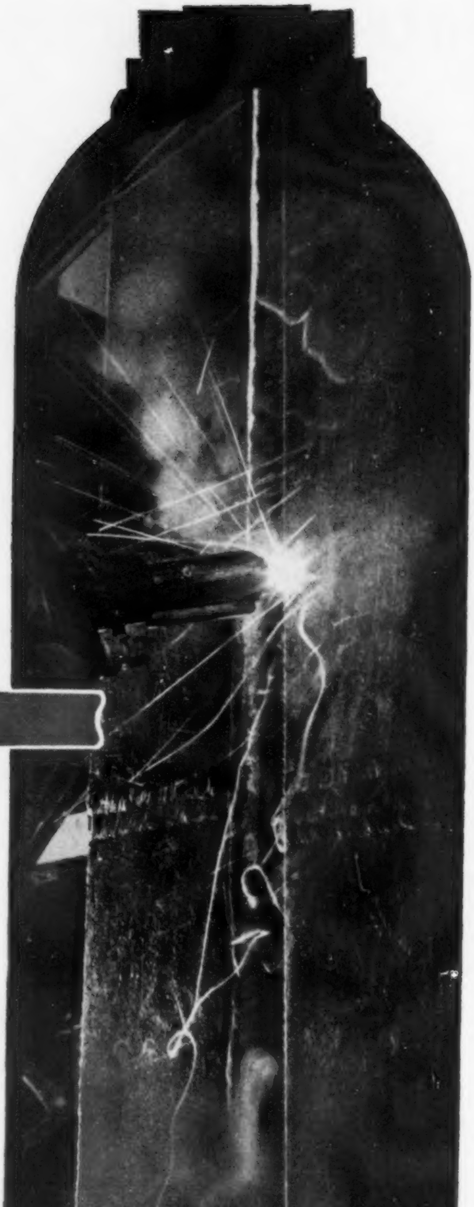

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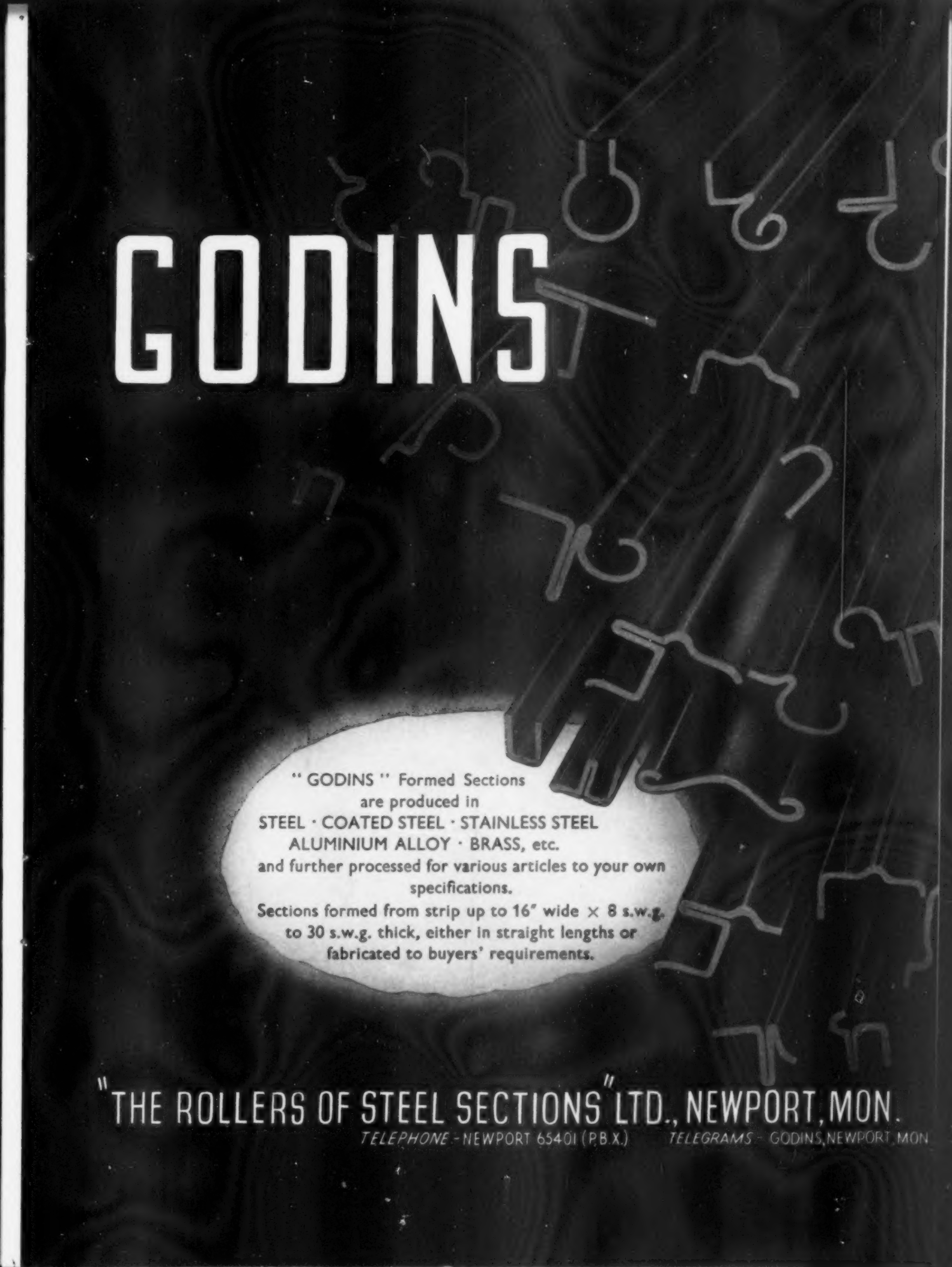
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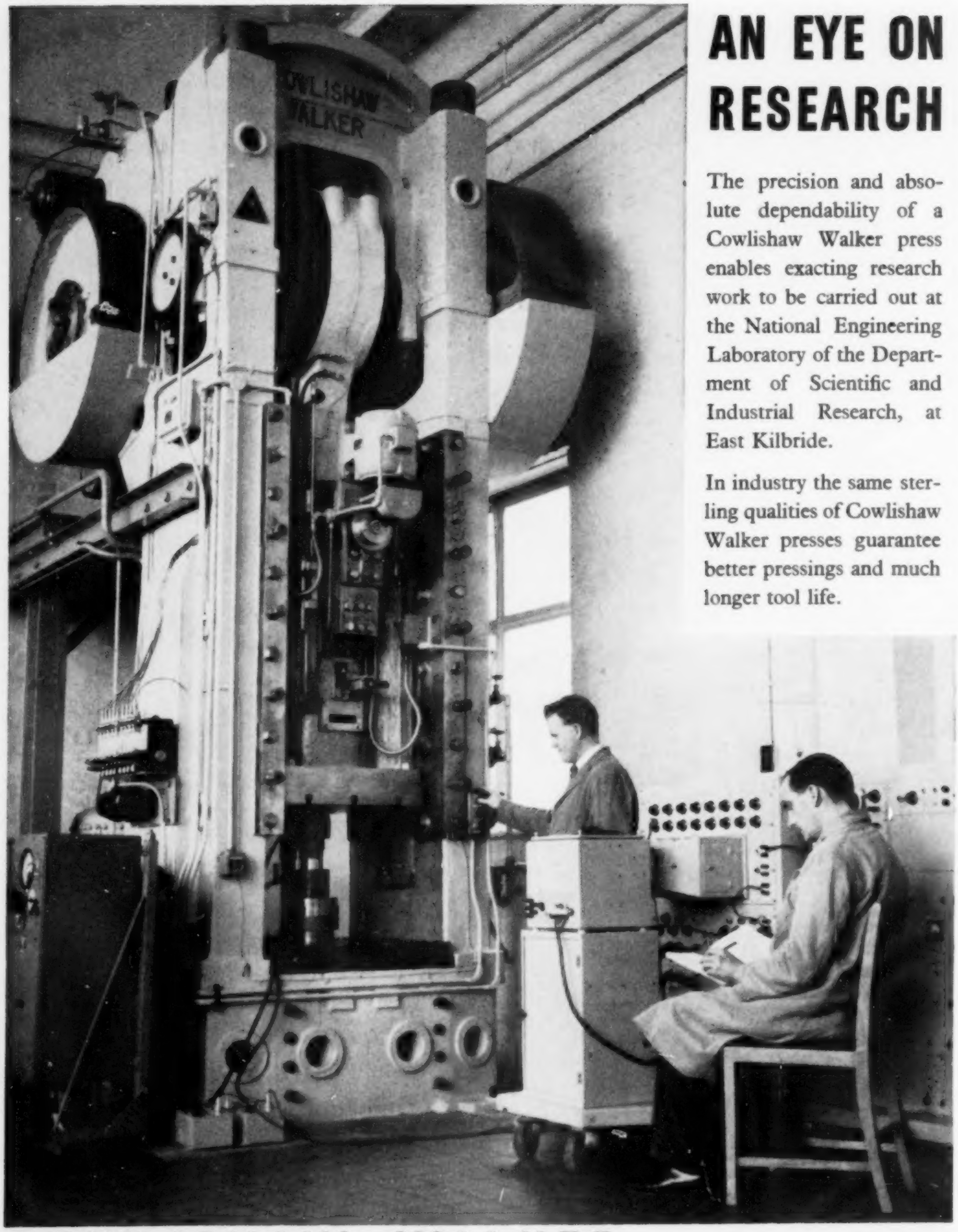

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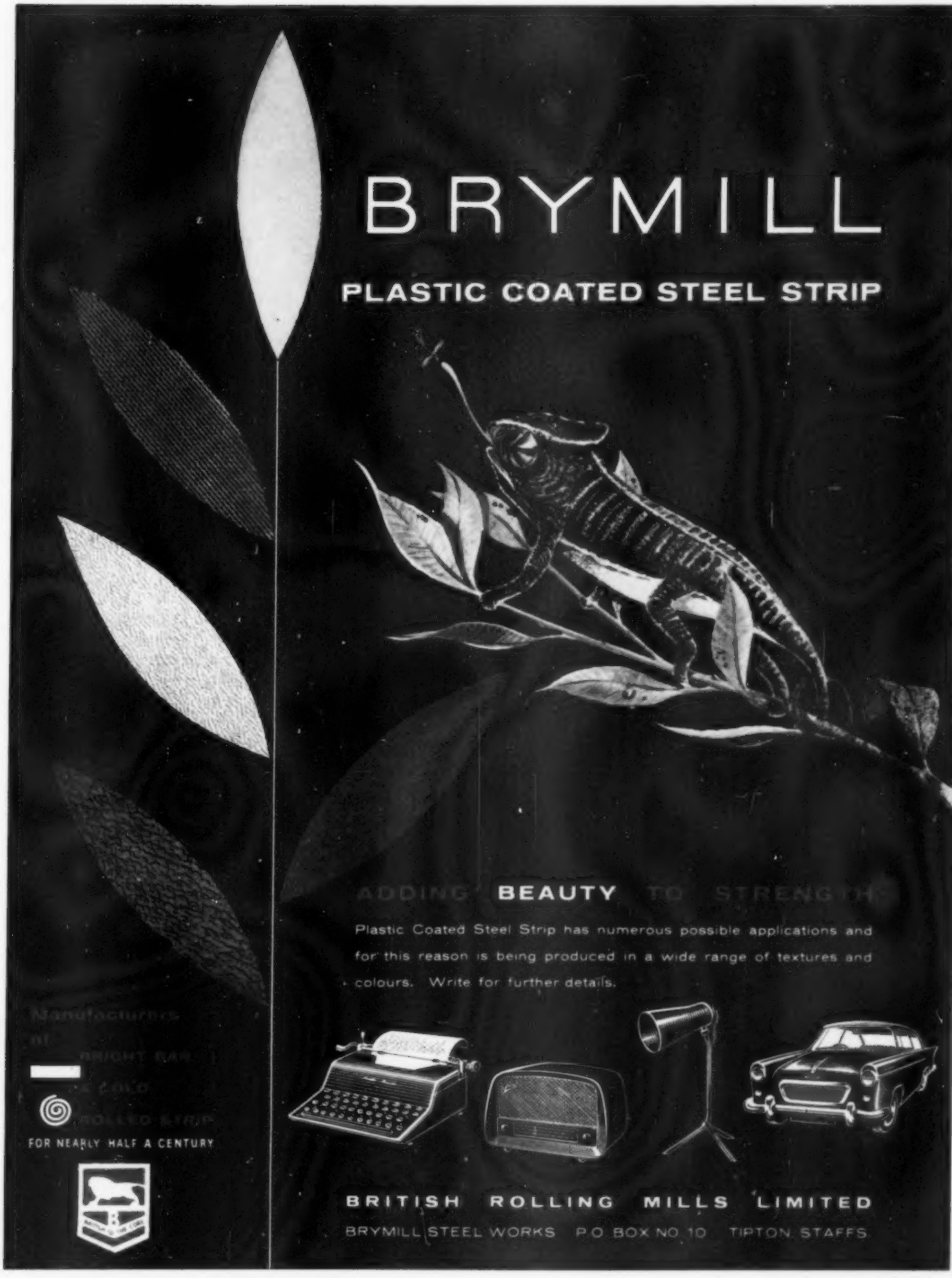
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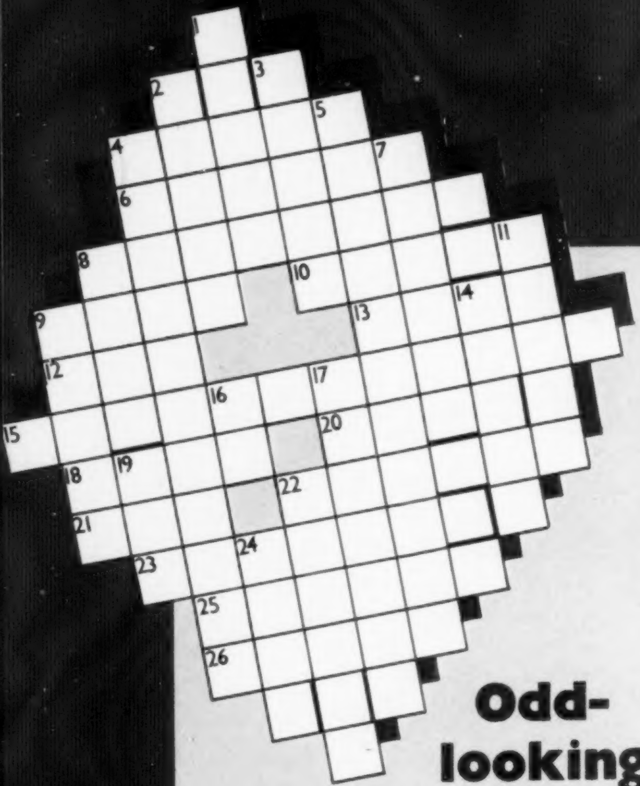

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- **10** Put oneself—or someone else—on the list (5)
- **12** Every detergent has this work unit (3)
- **13** Story of a gas blowback (4)
- **15** They have to be forceful (12)
- **18** She never made an original remark to Narcissus (4)
- **20** G.I. departed (4)
- **21** Don't broadcast this grief or the horse may stop (3)
- **22** Huron's assault (6)
- **23** Father's hour of recreation (7)
- **25** Line of signature (6)
- **26** When it's t'other way up, ancient mariners find it strange (5)

CLUES DOWN

- **1** West aid for the puppy (5)
- **2** Trim fruit (5)
- **3** The Indian elephant finds it just middling (5)
- **4** Chief persons in contract? They have an offensive role (10)
- **5** Changes down according to the current rules (11)
- **7** Breed that suffers from tension (6)
- **8** Might bring you damages (4)
- **9** Recruit to the Sappers? (5)
- **11** 50 vault over the tree (5)
- **14** Birds with horses' heads (5)
- **16** Negative return in 20 (2)
- **17** G.I. (inset) lights up (7)
- **19** Such I.O.U.s are abundant (3)
- **22** Fishing is literally their living (6)
- **24** Nothing more than a musical note in this part of London (4)

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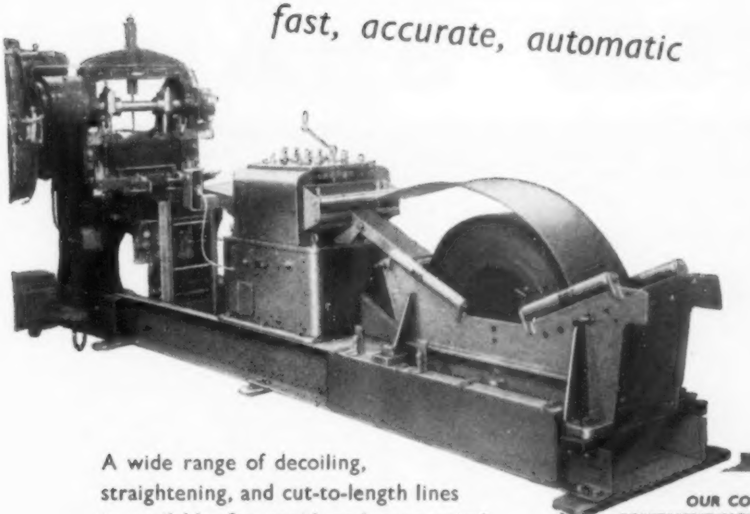

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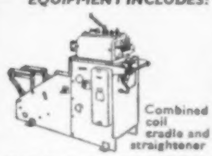

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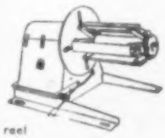

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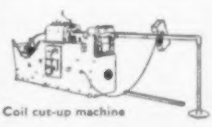

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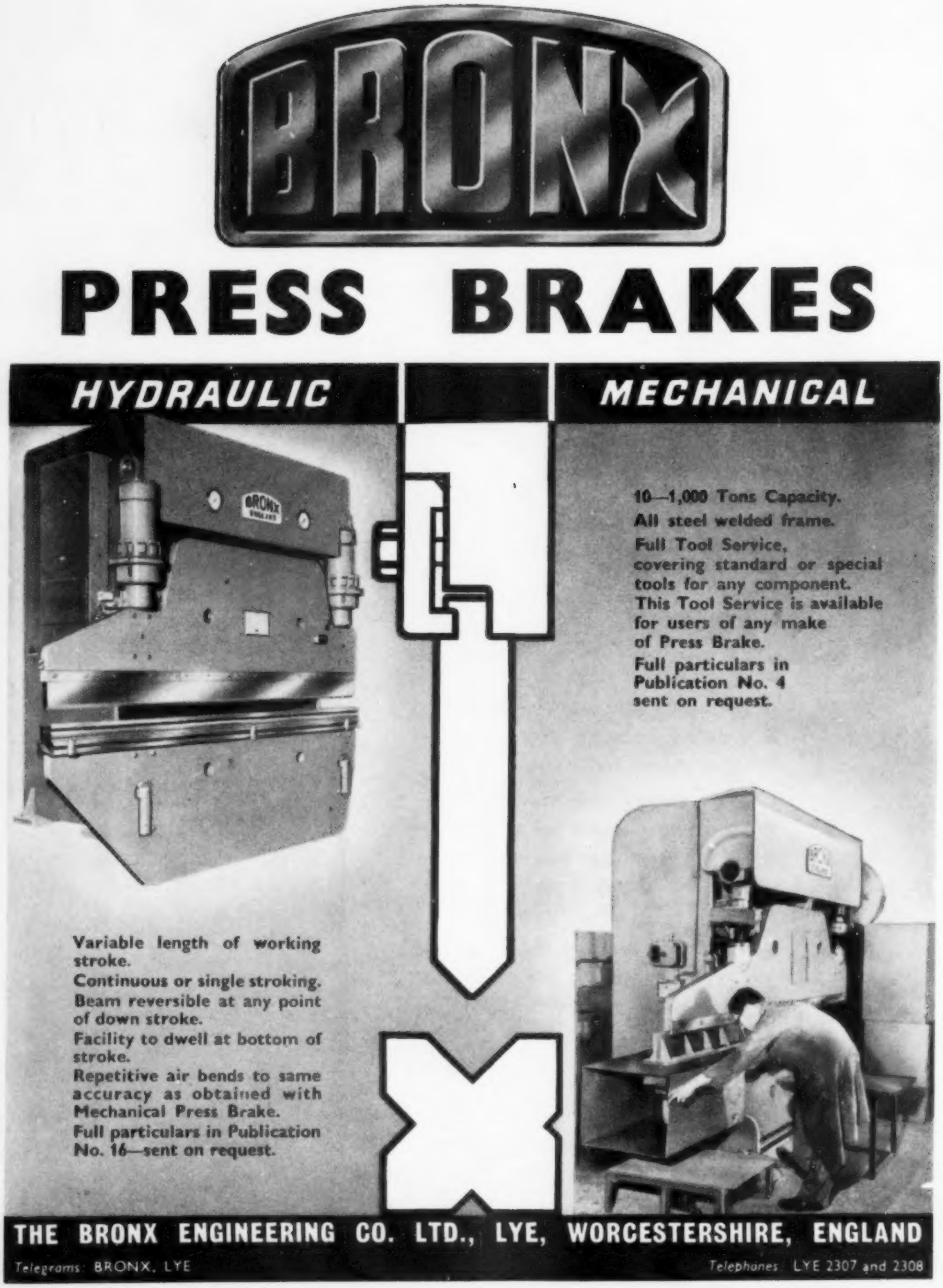
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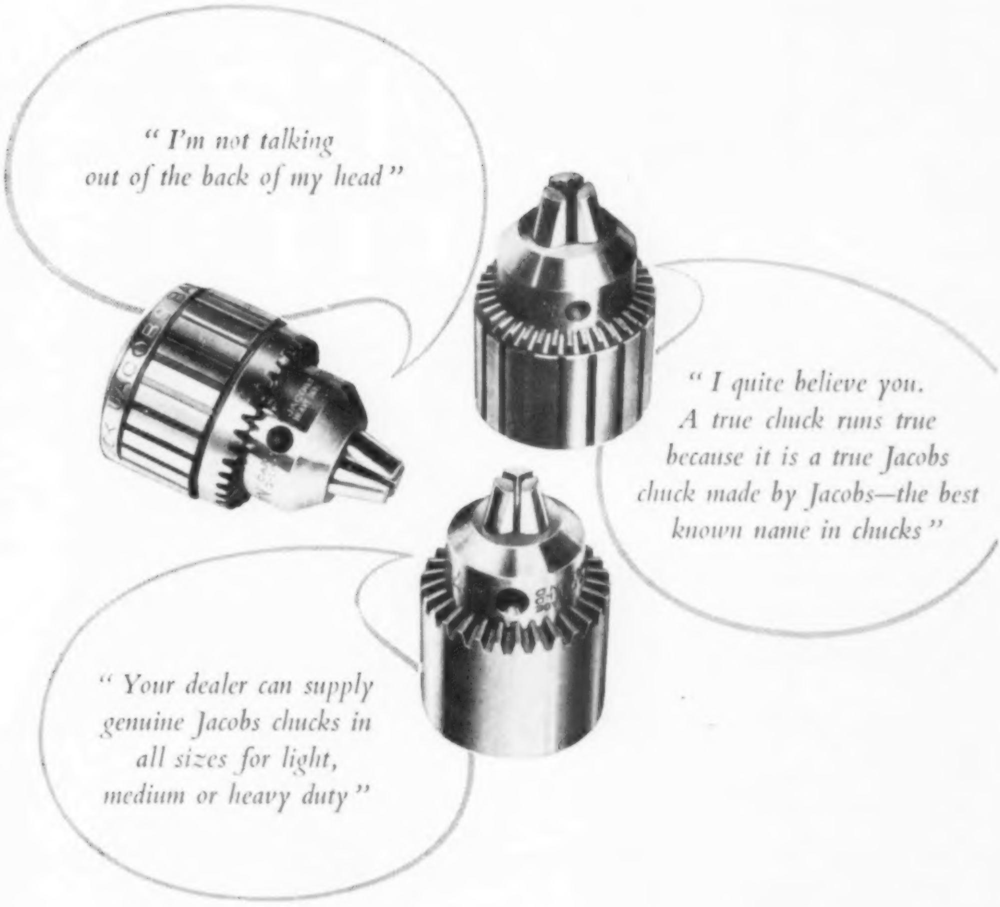

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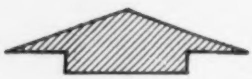

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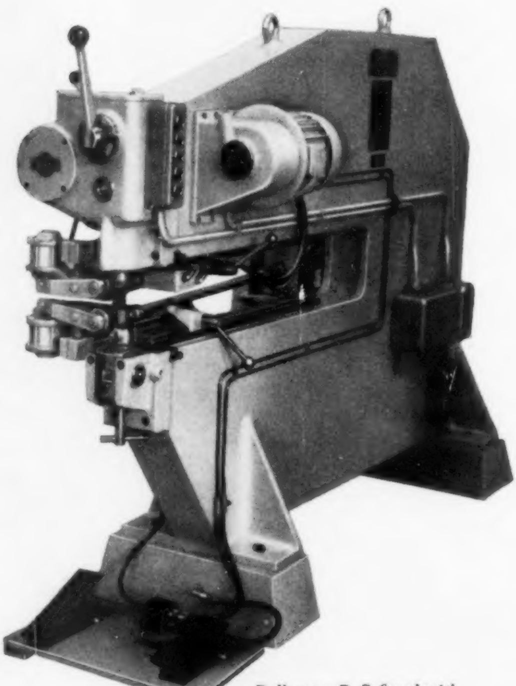

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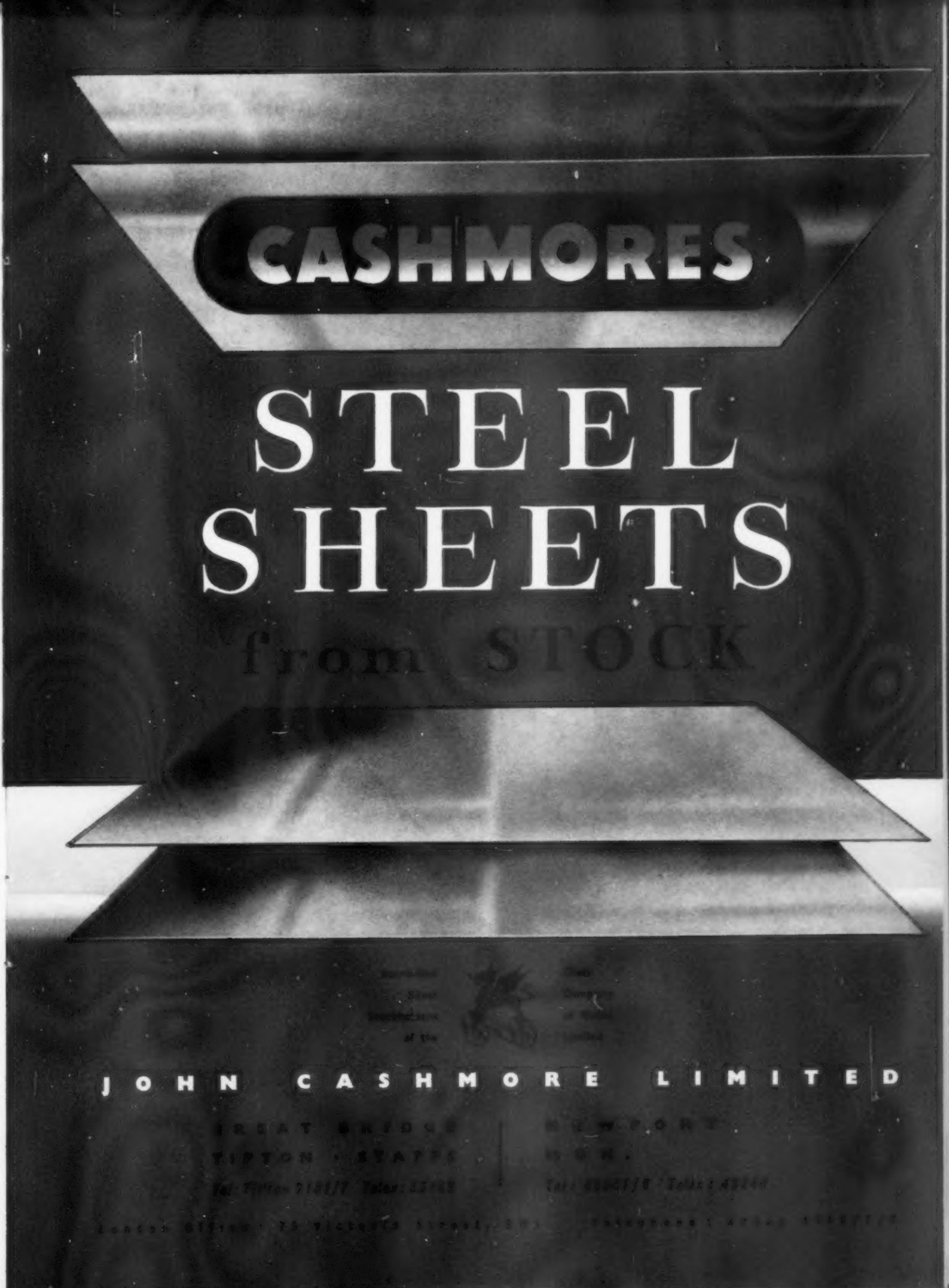
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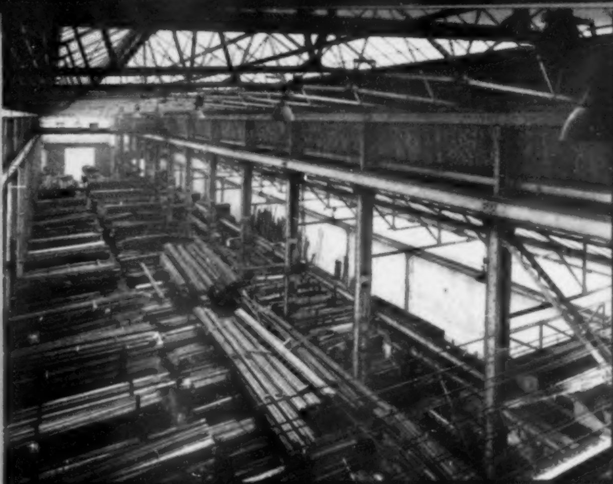

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FOR OUR OVERSEAS READERS

RÉSUMÉS DES PRINCIPAUX ARTICLES

Procédes de Production a l'usine de Beacon de la Société John Thompson Motor Pressings Ltd.—4 (suite) page 162

La fabrication des principaux organes de la partie inférieure dela caisse de l'Austin-Healey "Sprite" a été décrite dans le numéro de février du périodique SHEET METAL INDUSTRIES. *Le présent article décrit d'une manière détaillée le montage de ces organes en commençant par la fabrication des pricipaux sous-ensembles. Les principales opérations de montage se font par soudage par résistance, pour lequel un équipement spécial a été créé par la British Federal Welder and Machine Co. Ltd. L'article suivant dans cette serie décrira la production des cadres-caissons des voitures Rolls-Royce et Bentley.*

Phosphatation et Lubrification de l'acier pour le Refoulage à Froid .. page 171

Par D. James

Après avoir examiné la chimie du procédé de phosphatation, l'auteur considère un grand nombre de systèmes-types de lubrification et explique en détail une série typique de traitements par lesquels une billette d'acier devra normallement passer entre sa recuite et son introduction dans la presse à refouler. L'outillage nécessaire à une suite caractéristique de traitements préalables est également examiné. Ce mémoir, présenté à la conférence spéciale sur le "refoulement à froid de l'acier", organisée par l'institut des ingénieurs-tôliers (Institute of Sheet Metal Engineering), qui s'est tenue à Sheffield au mois de novembre 1960, est suivi du compte rendu du débat qui a fait suite à sa présentation.

Materiaux pour l'outillage dans le Procédé du Refoulage à Froid .. .. page 190

Par A. W. F. Comley, A.I.M., M.I.E.I., A.I.Prod.E.

Ce memoir a également été présenté à la conférence spéciale de l'I.S.M.E. (Institut des Ingénieurs-Tôliers) sur le

(Suite page 224)

ZUSAMMENFASSUNGEN DER HAUPTARTIKEL

Fertigungsverfahren im werk Beacon der John Thompson Motor Pressings Ltd. — 4 (Fortsetzung) .. Seite 162

In der Februarnummer der SHEET METAL INDUSTRIES *wurde die Herstellung der Hauptteile für die Unterkarosserie des Austin-Healey „Sprite" beschrieben. Der vorliegende Artikel schildert im einzelnen den Zusammenbau dieser Teile, beginnend mit der Montage der wesentlichen Untergruppen. Der Zusammenbau erfolgt vorwiegend durch Widerstandsschweißung, wofür Spezialgeräte von der British Federal Welder and Machine Co. Ltd. entwickelt wurden. Die Serie wird mit einer Beschreibung der Herstellung des Fahrgestells für Rolls-Royce und Bentley-Wagen fortgesetzt.*

Phosphatieren und Schmieren von Stahl für das Kalt-Strangpressen .. Seite 171

Von D. James

Nach einer Betrachtung der Chemie des Phosphatüberzugverfahrens behandelt der Verfasser viele typische Schmiersysteme und gibt eine eingehende Beschreibung einer typischen Behandlungsfolge, die ein Stahlblock normalerweise zwischen dem Glühen und dem Eintritt in die Strangpresse durchläuft. Die für eine typische Vorbehandlungsfolge nötigen Einrichtungen werden besprochen. Der Artikel, der im November 1960 auf der vom Institute of Sheet Metal Engineering organisierten Sonderkonferenz über „Kalt-Strangpressen von Stahl" in Sheffield als Vortrag gehalten wurde, enthält auch die anschließende Diskussion.

Werkzeugmaterialien für das Kalt-Strangpressverfahren Seite 190

Von A. W. F. Comley, A.I.M., M.I.E.I., A.I.Prod.E.

Dieser Artikel wurde ebenfalls als Vortrag auf der Sonderkonferenz der I.S.M.E. über „Kalt-Strangpressen

(Forts. S. 224)

RÉSUMENES DE LOS ARTICULOS PRINCIPALES

Procedimientos de Produccion en los Talleres Beacon de la John Thompson Motor Pressings Ltd.—4 (Continuación) .. .. pagina 162

En el número de febrero de SHEET METAL INDUSTRIES *se describió la producción de los principales elementos de la parte inferior de la carrocería del Austin-Healey "Sprite". Este artículo describe detalladamente el montaje de estos elementos, empezando por la construcción de los principales subconjuntos. Las principales operaciones del montaje se efectuan por medio de soldadura por resistencia, para la cual la British Federal Welder and Machine Co. Ltd. creó un equipo especial. El próximo episodio de esta serie describirá la producción del bastidor para los coches Rolls-Royce y Bentley.*

El Resvestimiento de Fosfato y la Lubricacion del acero para su Extrusion en Frio pagina 171

Por D. James

Después de estudiar la química del procedimiento de revestimiento de fosfato, el autor se refiere a muchos sistemas típicos de lubricación y describe detalladamente un ciclo típico de tratamiento a través del cual pasará normalmente el pedazo de acero entre el recocido y su entrada en la prensa estrujadora. También trata de la instalación necesaria para un ciclo típico de pretratamiento. Esta ponencia, que fué presentada durante la Conferencia especial sobre "Extrusión en frío del acero" organizada por el Instituto de Ingeniería de la Chapa Metálica en Sheffield en noviembre de 1960, va seguida de la discusión a que dió lugar su presentación.

Materias Primas para Herramientas para el Procedimiento de Extrusion en Frio pagina 190

Por A. W. F. Comley, A.I.M., M.I.E.I., A.I.Prod.E.

Esta ponencia también fué presentada durante la conferencia especial sobre "Extrusión en frío del acero" del

(Continuará en p. 224)

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THE WEAK LINK

OF all the industries in this country, and indeed in the world, that have made remarkable strides in the application of modern methods of production, that in which the forming of sheet metal is the essential part immediately becomes to mind. The production of motor cars, washing machines, gas cookers, etc. has been virtually revolutionized and it is only because of this that these products are available at prices that compare more than favourably with those reigning before the war.

But in spite of the tremendous capital expenditure lavished on new equipment (and here one should also include equipment for producing sheet and strip) it is not untrue to say that many of our products have met with adverse criticism both at home and abroad. Reference was made in this page last month to the absolute necessity to increase exports, but one might well reflect, for example, what effect these criticisms have had on the sale of our goods abroad.

But, in theory at least, the increasing use of automation and similar techniques in the production of any article whether large or small should ensure a high standard of quality and also make certain that this quality is maintained. There is no doubt that improved quality has been obtained in the production of individual *components* which when brought together make a complete article, and it is from here that one has to search for the weak link in what should be a homogeneous chain of processes.

The conclusion is forced upon us then, that somewhere in the actual *assembly* of an article there is a defection, because no matter to what degree production equipment may be automated, in the last analysis it is human skill and the care that the operative puts into his work that determine the final quality of a product. It can only be assumed, therefore, that there are shortcomings not only in assembly but perhaps also in inspection procedures so eventually reducing greatly the appeal of a product to customers. To take an example, should it become an accepted fact that the purchaser of a new motor car expects the period of about six months or so before all the "bugs" are eliminated, or should a new gas cooker require extensive attention during approximately the same period before it functions correctly ?

It would appear that there is a lack of pride on the part of the average operative in industry in the product he is helping to manufacture, and this is the most important "weak link" that must be strengthened. Let us by all means give prominence to the undoubted truth of the cry of "export or die," but also let management encourage labour to make a pledge to take a keen interest in their job, and to make a good job of this job. Although the system of bonus payments, etc. in use to-day does not help to achieve this, there must be some means by which the traditional British pride in craftsmanship can be revived to become a major selling point as it was not so many decades ago, and this means to an essentially laudable end must be found.

Production Procedures at the Beacon Works of JOHN THOMPSON MOTOR PRESSINGS Ltd.

Fabricating the Austin-Healey "Sprite" Underbody: Part 2

ASSEMBLY IN DETAIL

ASSEMBLY of the Sprite underbody involves a total of 2,066 spot welds in addition to arc welds and the attachment of nuts, etc., by projection welding. Arc welding is used to give additional strength at certain locations or to make a weld where it is impracticable to spot weld.

The general assembly run is from component feeder stores, to projection and pedestal welders, etc., to produce sub-assemblies, which are then transferred to the main assembly-line jigs and fixtures.

Sub-Assemblies

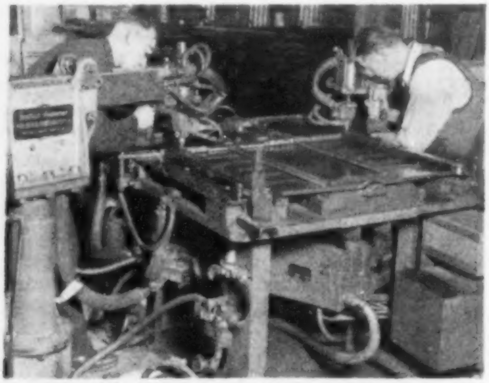
The components for the various main sub-assemblies are as follows :—

Main Beams (Fig. 67* : 2)

Each main beam itself has attached to it a bumper tube and ¼-in. weld nuts. The main beam closing plates (Fig. 67 : 3 and 4) are completed by weld nuts and a tapping block. Each main beam also incorporates an end closing plate (Fig. 67 : 5). Also in the main beam assembly are the bonnet-locating brackets and collars (Fig 67 : 6).

* For convenience Fig. 67, exploded view of " Sprite " underbody components, is reproduced in page 165.

Fig. 77.—*Radial-arm set-up in use*



Front-suspension Assembly

This consists of two spring brackets and bumper cups and spring bracket reinforcement. There is also reinforcement for the two front-suspension link brackets, a tapping strip for the spring brackets and the bumper cups, various weld nuts, and brackets to carry the hose to the front brakes.

Housing Support Assembly (Fig. 67 : 11)

Suspension housing supports (front and rear) are completed by the addition of various weld nuts.

Radiator Bracket Assembly (Fig. 67 : 16, 17)

The radiator brackets each have a tapping plate attached.

Centre Crossmember Assembly (Fig. 67 : 18)

This is completed by the addition of large and small spacers, and the jack tubes and their supports (Fig. 67.19).

Rear Crossmember Assembly (Fig. 67 : 20)

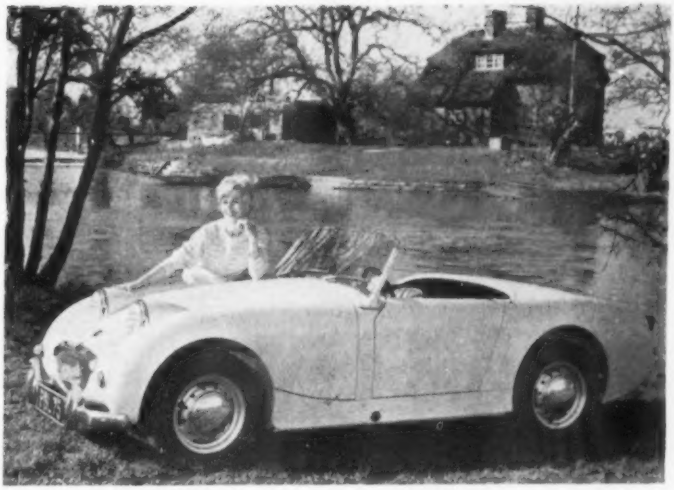
This consists of the front and rear panels, together with reinforcement, shock-absorber mounting plates (Fig. 67 : 21) various tapped bosses, hose brackets for the rear brakes, spring mounting plates (Fig. 67 : 22), wiring clips, various weld nuts and distance pieces and rear crossmember stiffeners.

Main Floor Assembly (Fig. 67 : 23)

This consists of the main floor, a slinging hole plate, various weld bolts and nuts, splash deflectors, and stiffening channels, doubling plates, etc.

Tunnel Assembly (Fig. 67 : 25)

The tunnel is completed by front and rear reinforcements to which nuts are welded, the tunnel channel and the handbrake abutment bracket (Fig. 67 : 26).



4 (contd.)

(Series continued from page 94, February, 1961)

Gearbox Cover Assembly (Fig. 67 : 27)

The gearbox cover incorporates reinforcement plates (two) and a reinforcement ring.

Inner Side-panel Assembly (Fig. 67 : 29, 30)

The pair of inner side panels are attached to the tunnel front panel. Two battery retainer lugs are attached and a wiring clip (left-hand panel only).

Main Panel—Footwell Assembly (Fig. 67 : 32)

Each footwell consists of front and top panels, side fixing strips, end fixing strips, various weld nuts and a wiring clip (right-hand only). Also added is the accelerator cable abutment bracket.

Outer Panel—Footwell Assembly (Fig. 67 : 34)

To these two panels various weld nuts and a wiring clip are added.

Frame Side-sill Assembly (Fig. 67 : 35)

Each side sill has two weld nuts attached, and a side-sill plate.

In addition, there is the heater platform (Fig. 67 : 39) to which ¼-in. weld nuts and the battery-starter switch are attached ; the heater closing plate (made from the metal cutout from the floor panel) to which four wiring clips are attached ; the front wheel-arch inner panels (Fig. 67 : 40, 41) complete with weld nuts ; the engine undershields (right and left hand) complete with weld nuts ; the front wheelarch tops (Fig. 67: 42, 43) completed by weld nuts and wiring clips ; the front wheelarch outers (Fig. 67 : 44, 45) ; spring mounting stiffeners and angles ; the front wheelarch inner gusset plates ; the side-plate closing members for the front wheelarch ; two stiffening plates (front wheel arch to front crossmember) ; two side plates ; splash plates ; and the ignition-coil bracket.

* * *

In planning production of the "Sprite" and in order to employ the most advanced welding techniques in the construction of the all-welded body frame, John Thompson Motor Pressings drew upon the specialist knowledge of British Federal Welder and Machine Company to plan the sub-assembly break down together with the jigging and welding equipment.

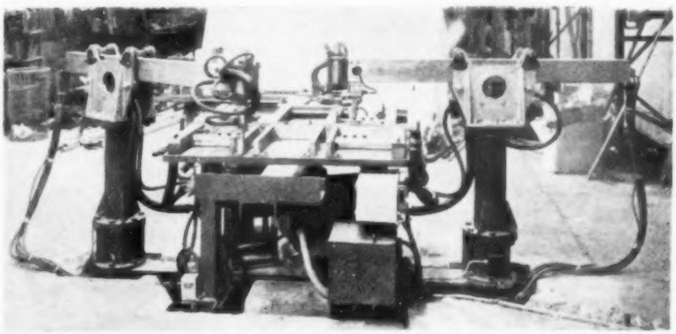


Fig. 78.—General view of radial-arm resistance-welding fixture

Fig. 79.—Arc welding front-suspension assembly to main beams on floor panel

The production required in the initial stages did not, of course, justify the installation of fully automatic multi-welding equipment and was, therefore, based on the use of standard machines comprising a mixture of static and portable types.

Nevertheless, it was possible to introduce a number of novel ideas with a view to reducing production costs and the handling fatigue associated with the use of large-throat guns. British Federal were responsible for the design and supply of the complete welding installation including all main and sub-assembly jigs and both standard and special-purpose welding equipments.

One of the main sub-assemblies consists of the floor panel which is reinforced on both upper and lower surfaces with a series of longitudinal and transverse stiffeners. As the reinforcements extend over the full area of the floor panel it would, clearly, require the use of very large and unwieldy guns to apply the large number of weld spots required and to eliminate the need for using such equipment a special combined location and welding fixture was designed. This "radial arm" fixture is illustrated in Figs. 77 and 78.

The fixture consists of fabricated jig table on which are mounted profiled die locators for positioning of the upper stiffeners—the floor is welded in an inverted position—and these are backed up by means of replaceable copper die strips connected electrically to two common points so as to provide as nearly as possible a uniform average length of secondary path. The lower reinforcements are located by means of a light jig frame placed over the panel and are clamped in position for welding. An additional refinement is the use of guide bars mounted over the assembly and by means of which the welding heads are located to provide the spot welds on the stiffeners mounted beneath the panel and which cannot be seen.

The machine has two independent welding heads which are carried from pillars mounted on a common base with the jig table. Each head is controlled from a double-acting air cylinder *via* a trigger switch on the head assembly and is mounted from a telescopic arm carried in free-running guide rollers by means of which it can be rapidly positioned at any required point on the assembly. To minimize effort both in extending the arm and in rotating it to the position required a specially-designed contact system is incorporated to complete the secondary circuit to the head only when actually welding. This system eliminates the need for trailing cables or bus bars and thereby provides a maximum of flexibility. The telescopic arm assembly rotates freely in ball bearings fitted to each pillar. The machine is powered from two independent portable-type transformers mounted beneath the jig table and as described above the connexions of the secondary circuit are designed to provide, as far as possible, a uniform path. Some variation in

Fig. 67 (facing page).—Key to underframe components

1. *Member assembly—frame side (R/H).*
2. *Member assembly—frame side (L/H).*
3. *Plate assembly—closing—side member (R/H).*
4. *Plate assembly—closing—side member (L/H).*
5. *Plate—end closing—side member.*
6. *Bracket—bonnet locating.*
7. *Cross member—front.*
8. *Plate—closing—front cross member.*
9. *Spring bracket assembly—front suspension (R/H).*
10. *Spring bracket assembly—front suspension (L/H).*
11. *Support assembly—suspension housing.*
12. *Bracket—front—front suspension link (R/H).*
13. *Bracket—rear—front suspension link (R/H).*
14. *Bracket—front—front suspension link (L/H).*
15. *Bracket—rear—front suspension link (L/H).*
16. *Bracket assembly—radiator mounting (R/H).*
17. *Bracket assembly—radiator mounting (L/H).*
18. *Cross member assembly—centre.*
19. *Support assembly—jack tube.*
20. *Cross member assembly—rear*
21. *Bracket assembly—shock absorber mounting (L/H).*
22. *Plate—spring mounting.*
23. *Floor assembly—main.*
24. *Channel assembly—stiffening—main floor.*
25. *Tunnel assembly.*
26. *Bracket—hand brake abutment.*
27. *Cover assembly—gearbox.*
28. *Panel—tunnel front.*
29. *Panel assembly—inner side—foot well (R/H).*
30. *Panel assembly—inner side—foot well (L/H).*
31. *Panel assembly—foot well front and roof (R/H).*
32. *Panel assembly—foot well front and roof (L/H).*
33. *Panel assembly—outer—foot well (R/H).*
34. *Panel assembly—outer—foot well (L/H).*
35. *Plate—side—sill (L/H).*
36. *Strut—front suspension (R/H).*
37. *Strut—front suspension (L/H).*
38. *Support—heater platform.*
39. *Platform assembly—heater.*
40. *Wheel arch assembly—inner (front R/H).*
41. *Wheel arch assembly—inner (front L/H).*
42. *Wheel arch assembly—top (front R/H).*
43. *Wheel arch assembly—top (front L/H).*
44. *Wheel arch—outer (front R/H).*
45. *Wheel arch—outer (front L/H).*

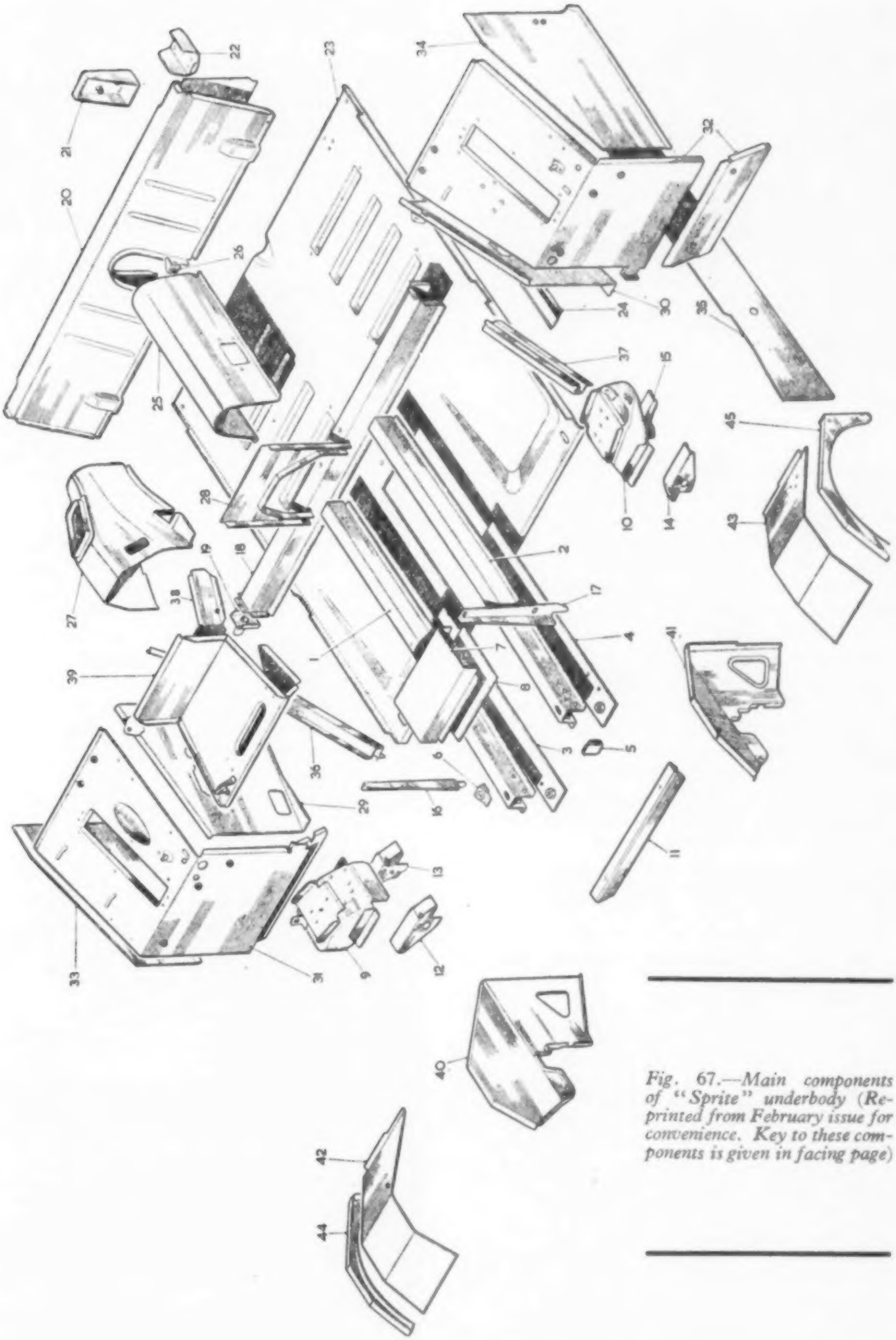


Fig. 67.—Main components of "Sprite" underbody (Reprinted from February issue for convenience. Key to these components is given in facing page)

Fig. 80.—British Federal plug-in type fully-interlocked sequence timer

heat does, however, occur as the arms move from one extrememity of the assembly to the other and to ensure a uniform weld quality the machine is controlled from a plug-in type specially-designed electronic timing unit giving self compensating control. As the weld current varies the timer automatically compensates to provide what is, in effect, a constant energy circuit and no other adjustment is necessary.

In addition to the main assembly spot welding it was required to projection weld a number of studs to the floor. The machine was supplied with special adaptors to enable this operation to be carried out and the control system employs a dual phase-shift setting by means of which the correct heat level can be preset and thereafter selected as required by the use of a switch mounted on the welding head proper. The centre crossmember is attached by the A.R.O. gun previously described. Also added are various brackets, stiffeners, etc. The complete front suspension assembly is arc welded on together with the front crossmember assembly and the radiator brackets, Fig. 79.

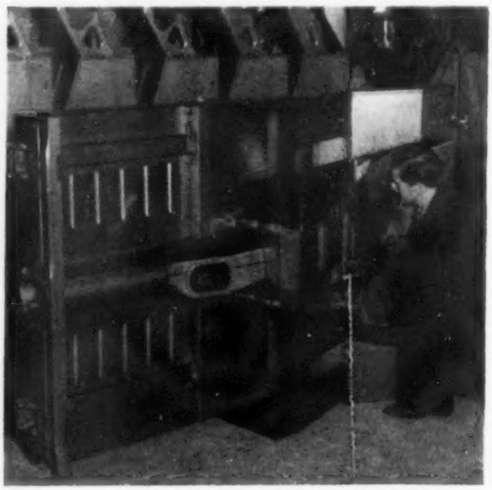
The radial-arm fixture described above in some detail was the only welding equipment of completely special design throughout. A number of additional machines—mainly projection welders—were supplied with specially-designed tooling units for multiple spot welding small sub-assemblies and for projection welding of a number of attachments to various pressings. These are outlined in the breakdown which follows. The main and sub-assembly fixtures were specially designed in every case and the greater part of these were of floor-mounted type and used in conjunction with portable welding installations all provided with suitably designed heavy-duty air-operated guns.

To provide for maximum flexibility combined with a minimum installation cost a number of portable welding installation were of the dual-gun type. Thus it was possible, while using a single transformer and control, to employ two separate guns, each designed to provide access to a particular section of the assembly. These dual equipments were controlled by means of the British Federal standard WFO2 A plug-in type fully interlocked sequence timer (Fig. 80) which provides independent timing control on each gun and also interlocks the air controls to prevent initiation of a gun while its associated unit is in use.

This timer is one of a range of similar units which are fitted throughout the installation and each class of timer follows the same basic construction so that they can be connected directly to the controlling air valve, contactor and initiating switch without the use of additional relay circuitry. Since the timers are of plug-in construction maintenance is reduced to a minimum, and this standardization of controls is a factor of major importance, not only in reducing actual maintenance costs but in minimizing the quantity of spare parts which have to be held in stock.

The same policy continues in relation to new developments since at the present time great strides continue to be made in the field of welding control equipment. The latest British Federal timer is a four-stage high-speed fully transistorized unit employing pointed circuits throughout and giving a fully interlocked control of the entire machine operation. This new unit is completely interchangeable with the previous types both with regard to the physical fitment of the chassis into existing enclosures and the plug-in connexions. This means that users such as John Thompsons can

Fig. 81.—Complete underbody frame; operator is here carrying out some final arc welding



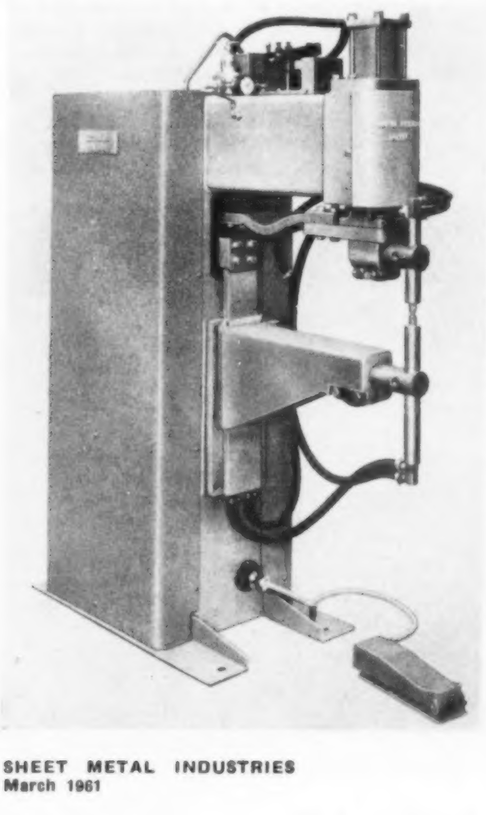
replace existing models with the very latest type of timer as and when required and with a minimum of time and cost.

The remainder of the body construction is subdivided into a number of assemblies which are located and welded progressively to form the complete body frame illustrated in Fig. 81. Manual transfer is employed between adjacent fixtures and the main subdivisions are generally as follows :

Operation 1. Sub-assembly of tunnel is carried out in two stages, the first of which is used to projection weld nuts to the reinforcement bracket. The latter is then located by means of a portable jig and spot welded on a standard 50-kVA pneumatic spot welder, Fig. 82.

Operation 2. Assembly of gear-box cover and tunnel is effected in a specially designed fixture for location and clamping of the two main components together with the tunnel front panel and reinforcement plates holding these in accurate relationship. The reinforcement plates incorporate weld nuts attached by a 150-kVA machine. A special feature included in the fixture is a reaction-type gun which follows a profiled track to provide welds around the junction of the tunnel and gearbox.

Fig. 82.—British Federal 50-kVA pneumatic spot welder



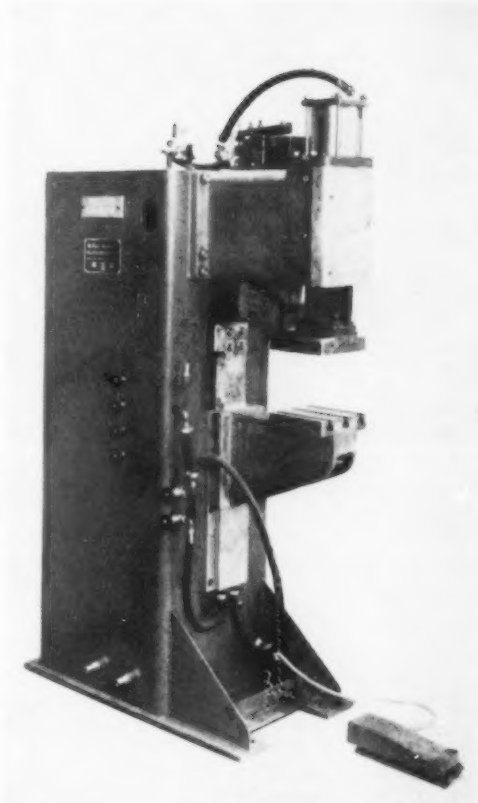


Fig. 83.—Projection welder (British Federal) for attaching weld nuts

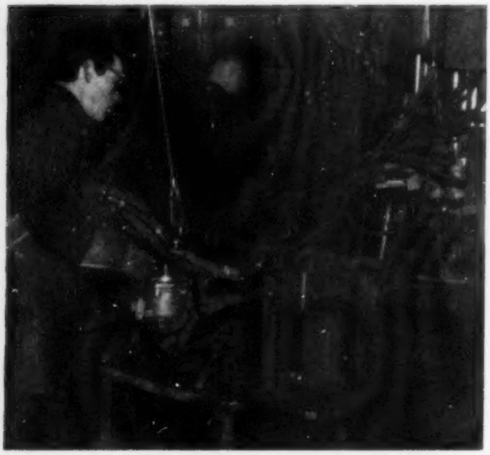
The remainder of the resistance welding is done with a 50-kVA portable spot-welding equipment. The hand-brake abutment bracket is attached by arc welding.

Operation 3. After applying weld nuts on a standard projection-welding machine (Fig. 83) the rear crossmember reinforcements, right and left hand, are assembled in a portable fixture used to locate and clamp shock-absorber plate, crossmember reinforcement and spring-mounting bracket which are welded on a 50-kVA pedestal-type spot welder fitted with special electrodes.

Operation 4. Sub-assembly of the complete rear crossmember is carried out in 3 main stages—

(*a*) Crossmember reinforcement assemblies from Operation 3 are fitted to the panel and located through holes which have to be held in accurate alignment. Welding is carried out on a 50-kVA standard spot welder.

(*b*) Front and rear panels are loaded into a specially-designed floor-mounted fixture together



with the tunnel assembly and reinforcements and accurately located and clamped.

Welding is carried out by a dual portable spot-welding equipment with two specially-designed guns used to weld reinforcement brackets to the front panel, tunnel to front and rear panels and tack weld front panel to rear panel in approximately three places.

(*c*) The assembly is removed from the fixture and turned over onto a support table on which a single portable welder is used to complete the welds between front and rear panels and tunnel.

The distance pieces are arc welded to the rear panel at the appropriate stage.

Operation 5. In the sub-assembly of front suspension spring bracket, spring bracket reinforcement, and bumper cup, weld nuts are applied on a pedestal-type air-operated projection welder after which the spring bracket and bumper cup are assembled by use of pin-type locators and welded on a 50-kVA spot welder.

Operation 6 is to sub-assemble the front crossmember. A specially adapted air-operated spot welder is used for welding the closing plate to the front crossmember and to the main beam, Operation 7. The machine, which is of standard design is fitted with a rocking-type, dual-electrode, compensating upper head and a fixed twin electrode lower die by means of which both flanges of the crossmember are welded to the closing plate at each stroke. The two pressings are fed through the machine between guides positioned adjacent to the electrodes and using a high-speed repeat operation.

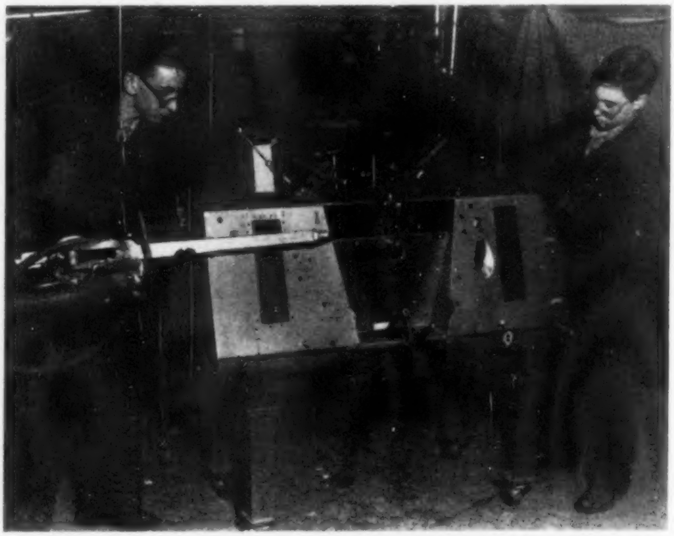
Operation 7. Assemble main beams. Weld nuts are applied on a pedestal-type 150-kVA air-operated projection welder with self-compensating-type dual tooling used for simultaneous welding of two nuts. The closing plate is welded on the dual spot welder as Operation 6.

Operation 8. Assembly of centre crossmember. In this operation spacers are welded to the crossmember. The spacers are located by loose jig bars and welded on a 50-kVA spot welder. The jack tubes are attached by arc welding. Support brackets are previously arc welded on to the jack tubes.

Operation 9. In the assembly of the wheel arches, weld nuts are attached to the inner panels using the projection welder as Operation 7. The wheel arch

Fig. 84 (*above*).—*Spot-welding wheel-arch top to inner panels*

Fig. 85 (*right*).—*Specially-designed fixture for assembly of heater platform*



top is spot welded to the inner panel on floor-mounted fixtures to accommodate right- and left-hand components and using a portable spot-welding gun (Fig. 84).

The front suspension strut is then welded to the wheel-arch inner panel using loose location fixtures and a 50-kVA spot welder and the wheel-arch outer panel is welded to the top panel in the same fixture as that used for the wheel-arch top sub-assembly and using the same portable welding equipment.

Operation 10. The heater duct assembled in four stages :

(*a*) Attachment of small brackets to the closing plate is carried out on a 50-kVA spot welder using a loose jig for location.

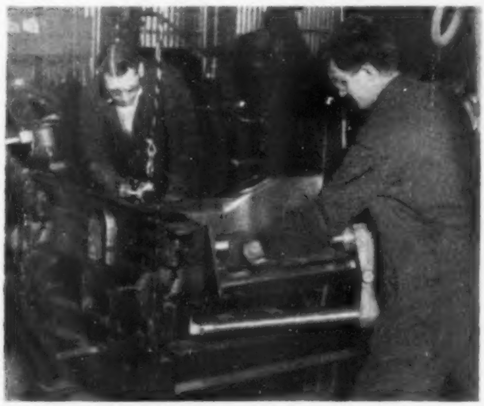
(*b*) Weld nuts are applied to the heater platform on a standard projection welder.

(*c*) The heater duct closing plate is welded to the heater platform support on a specially adapted

Fig. 86 (above).—Final assembly fixture

Fig. 87 (below).—Welding tunnel, etc., to main floor panel

Fig. 88 (right).—Rotary welding fixture



projection machine used as a multispot welder. A specially designed multi-head self-compensating tooling with a series of spot-welding electrodes is used for sizing and welding the assembly on three inclined flanges.

(*d*) The special tooling of (*c*) is employed for welding the heater platform to the support.

Operation 11. Weld battery lug to the inner side panel using standard spot welder and loose location jig. In addition spot welding is used to attach a wiring clip.

Operation 12 is to assemble the footwells:

(*a*) Weld brackets to main panel footwell using standard spot welder with loose jig.

(*b*) Attach weld nuts to main panel footwell using standard projection welder.

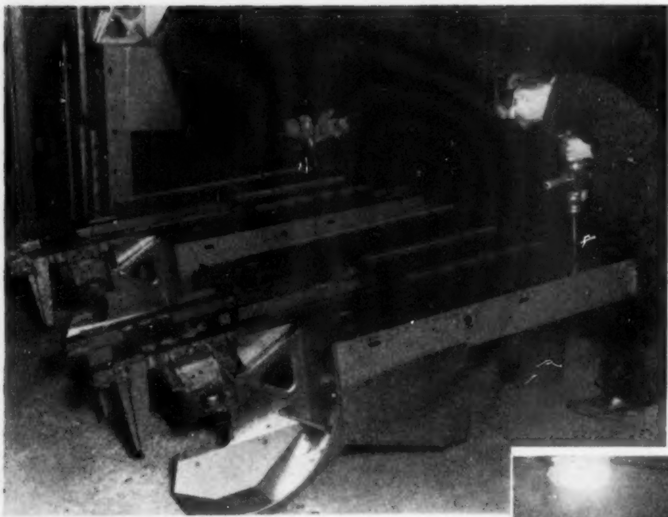
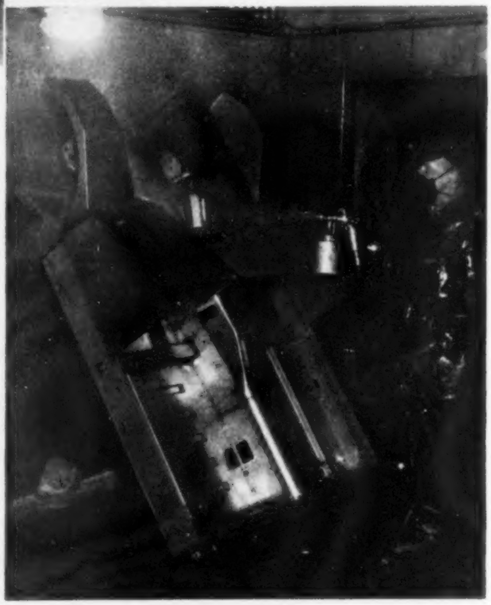


Fig. 89 (left).—Final operations on complete frame include tapping holes and freeing already tapped holes of weld splatter

Fig. 90 (below).—Complete frame is oil-sprayed to inhibit corrosion



(*c*) Attach weld nuts to reinforcement strip for main panel footwell using same machine as (*b*).

(*d*) The reinforcement strips are spot welded to the main panel footwell on a standard spot welder using a portable fixture.

Operation 13. Assembly of heater platform to bulkhead is effected in two stages :

(*a*) A specially designed fixture (Fig. 85) gives a two-part assembly ; first, locating the platform and inner side panels which are welded with a portable spot welder

(*b*) The bulkhead assembly is completed by adding—in the same fixture—the upper and front panels which are welded in position with portable equipments.

Operation 14. The assembly from Operation 13 is located on a specially-designed fixture together with the wheel-arch assemblies, and welded by the use of a dual portable spot welding equipment.

Operation 15. *Final Assembly*

A specially designed fixture (Fig. 86) is used for location of the main sub-assemblies in the following order :

Sub-assembly of floor from radial arm fixture is located on the fixture.

The rear crossmember assembly is added and clamped in position while the tunnel itself is self locating at the forward end.

Welding is carried out between tunnel, rear members and floor using one pair of the two dual portable spot welding machines operating with this fixture (Fig. 87).

The front assembly from Operation 14 is added to complete the main assembly and is located.

Welding is completed by the use of portable welding guns.

Operation 16*A*. *First Finishing Stage*

This stage is employed for adding the sills and welding them to the floor and rear panels. John Thompson Motor Pressings designed two special rotary fixtures for location of the sills (Fig. 88) and these are gun welded.

Operation 16*B*. *Second Finishing Stage*

Gas welding where required, is carried out to complete the assembly (Fig. 81).

(*Continued in page* 222)

PHOSPHATE COATING AND LUBRICATING STEEL FOR COLD EXTRUSION

(*A paper presented at the Special Conference on the "Cold Extrusion of Steel", Sheffield, November* 1960, *organized by the Institute of Sheet Metal Engineering*)

by D. JAMES*

Introduction

THE use of phosphate coatings as an aid to the cold working of steel is now a well established practice. It owes its origin to the work of Dr. Fritz Singer in Germany, who filed a patent as early as 1934(1), pointing out that the disadvantages of metal-to-metal contact in the cold working of metals could be avoided by the use of surface coatings such as metallic oxides or salts. For the cold working of iron and steel, phosphate or oxalate coatings were recommended.

Very little practical use was made of Singer's invention before the second World War, but during that period, the use of phosphate coatings to aid the cold working of steel was exploited on a very large scale in Germany. Indeed it is reported that the company producing most of the phosphating chemicals in that country—Metallgesellschaft A.G. —sold 67 per cent of its output for cold forming applications during the period 1943-1944(2).

At this time, of course, the vast majority of the phosphate coating of steel was being carried out in the steel-tube industry, and in assisting conventional deep-drawing operations. However, as is now well known, the cold extrusion of steel was being carried out on a production scale in Germany at this time.

The idea of extruding steel cold originated at the Neumeyer Metal Works, Nuremburg in 1935 when a mild-steel blank was fed into a press being used for the production of cartridge cases from 0.60-in. thick brass(3). The results showed promise and formed the basis of a German patent(4). It was obvious, however, that a suitable lubricant system had to be developed, and the basis of this existed in phosphate coatings impregnated with various lubricants.

In the intervening period, considerable research and field-trial work has resulted in the development of phosphate coating and lubricant systems which will permit the severe extrusions which are carried out today.

Phosphate Coating

Without going in extreme detail into the very complicated reactions which take place when a phosphate coating is produced at the surface of a piece of steel, it may be of some interest to discuss the nature of the reactions, and of the coating produced in general terms.

When a piece of chemically clean steel is immersed in a typical zinc phosphate solution, coating takes place in the following manner :— Reaction occurs between the solution and the steel surface altering the primary phosphate-phosphoric acid equilibrium at the metal/liquid interface, resulting in the deposition of insoluble heavy-metal phosphates.

A reaction intermediate between (i) and (ii) takes place :—

(i) $3Zn(H_2PO_4)_2 + 6Fe \longrightarrow Zn_3(PO_4)_2 + 2Fe_3(PO_4)_2 + 6H_2$,

(ii) $3Zn(H_2PO_4)_2 + 2Fe \longrightarrow Zn_3(PO_4)_2 + 2Fe(H_2PO_4)_2 + 2H_2$.

These are the extremes ; (i) represents all the dissolved ferrous iron going into the coating, (ii) represents all the dissolved ferrous iron going into the solution. The hydrogen is depolarized by simple oxidation :—

(iii) $6H_2 + 6O \longrightarrow 6H_2O$

and if the depolarizing agent is also a sufficiently powerful oxidizing agent, then ferrous iron is oxidized out of solution :—

(iv) $2Fe(H_2PO_4)_2 + O \longrightarrow 2FePO_4 + 2H_3PO_4 + H_2O$.

It has been found in practice that zinc phosphate coatings are very considerably superior to those of any other metal in assisting severe cold-working operations, and therefore it is this type of process which is invariably chosen for use prior to cold extrusion. The coating formed consists pre-

*The Pyrene Co. Ltd., Metal Finishing Division.

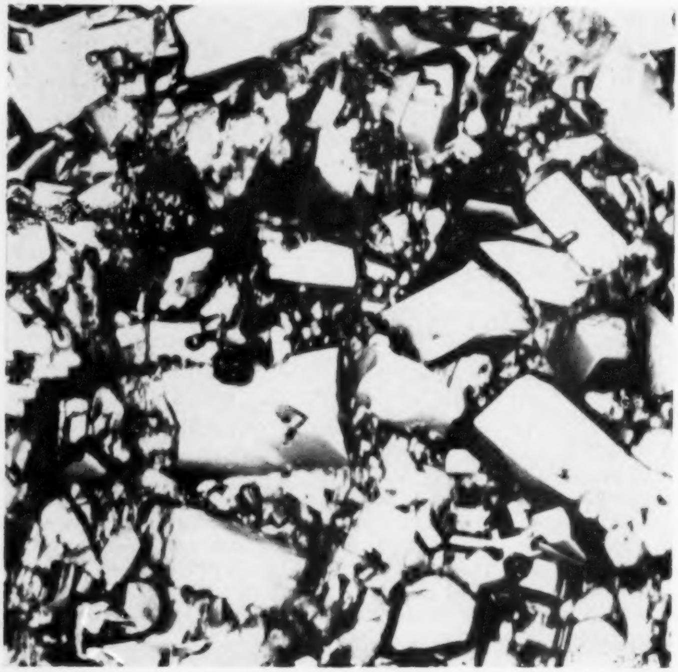


Fig. 1.—(×284) Photographs showing the crystal formations deposited on pickled steel surfaces by various types of phosphating solutions
(a) (left) Manganese/iron phosphate
(b) (below) Iron phosphate

dominantly of zinc tertiary phosphate ($Zn_3(PO_4)_2 4H_2O$), usually in the ortho-rhombic form identical with that of the mineral hopeite. Various reasons have been put forward for the superiority of zinc phosphate coatings over others, but the most probable reasons are as follows :—

(1) It has now been proved beyond doubt that reaction takes place between the zinc phosphate coating and the subsequent lubricant in many cases when the phosphated component is immersed in the lubricant bath. Specially developed reactive lubricants have been produced to take advantage of this property and will be discussed in more detail at a later stage. However, it is known that the zinc soaps formed in conjunction with zinc phosphate coatings have much better lubrication

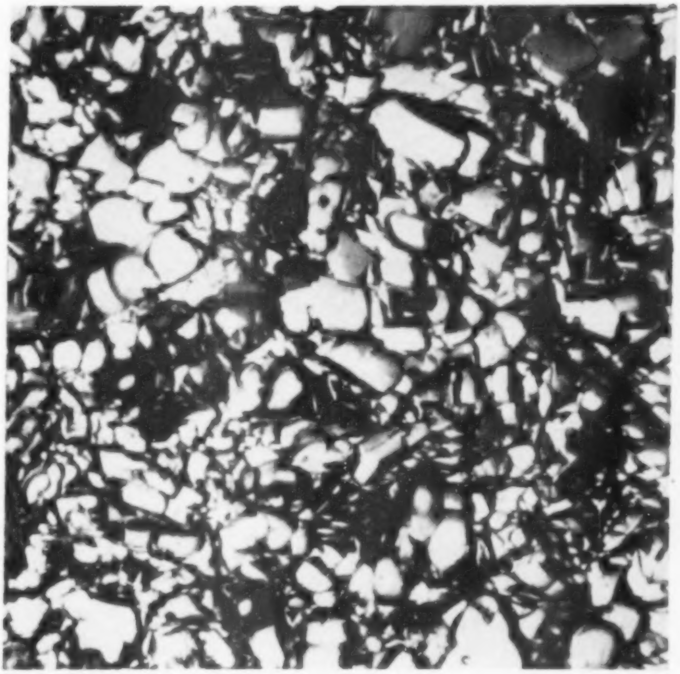


Fig. 1.—Continued from previous page
(c) (right) Zinc/iron phosphate
(d) (below) Zinc phosphate
[*Courtesy of The Pyrene Co. Ltd.*

characteristics under high unit pressures than those of alternative metals, notably iron and manganese.

(2) The crystal structure produced by an accelerated zinc phosphate solution possesses plastic properties under the conditions of temperature, pressure and shear stress which exist where severe cold working is being performed. The coating probably behaves, therefore, in a similar manner to a very high viscosity lubricant[5]. This behaviour would account for the property possessed by adherent zinc phosphate coatings of following the plastic deformation of steel even where it is forced to flow over die contours of very small radii.

(3) Under severe cold-working conditions, while some coating is removed, most of it is converted into a glass-like film. Microscopic and X-ray examinations of such films produced by cold working, carried out in Germany, suggest that the explanation for this condition is the fragmentation of the crystal aggregates and the instantaneous fritting together of these fragments, into a strongly adherent film, which, in turn, is strongly adherent to the base metal.

(4) Zinc phosphate processes have certain operational advantages in that the massive coatings generally required for cold extrusion can be formed quickly, thus avoiding an unduly cumbersome plant layout, and the working temperatures are generally lower than those for iron or manganese phosphate solutions. The ultimate crystal structure is also far less sensitive to previous pickling operations. They are also the most economical solutions to operate.

It is possible to deposit phosphate coatings varying considerably in thickness. However, due to the crystalline form of the coating and its comparatively soft nature, and also the fact that the original metal surface cannot be taken as a datum line, it is usual, when measuring coatings to determine the weight deposited per unit area rather than the actual thickness, although such coating measurements have been made and show that coatings vary approximately between 0.5 and 20 microns. A thickness of 10 to 15 microns corresponds approximately to a coating weight of 1.0 to 1.5 gm. per sq. ft.

Coating weight is normally determined by processing a sample piece of steel, of exactly the same specification as that being used for the components being treated. The sample is processed through an exactly similar sequence of operations to that used in production as far as the phosphating stage, it is then water-washed and dried. After careful weighing the coating is completely removed by immersion in either hot caustic soda or well-inhibited cold hydrochloric acid. After further washing and drying the sample is reweighed when calculation of the coating weight is a simple matter. The weight of zinc phosphate coating deposited, depending on the solution formulation, degree of pre-pickling, immersion time, and the use of such techniques as coating refining agents, either as separate pre-dips, or combined with the phosphating solution itself, may vary from as little as 150 mg. per sq. ft. to coating weights in excess of 4 gm. per sq. ft.

Considerable differences of opinion exist concerning the optimum coating weight of zinc phosphate to be used in conjunction with the cold-extrusion technique. Fischer has stated that he had no evidence of difficulties due to the coating being too thick, trouble only being experienced when it was too thin(7). However, production experience has suggested that unduly heavy phosphate/lubricant films can introduce problems, particularly when components are being extruded at a high production rate. Excess lubricant film is sheared off the slugs and packs into punch and die contours, causing variations to occur in the shape of the extruded component. Valuable production time is lost when these tools have to be cleaned. Additionally, use of excessively heavy coating and lubricant films is bound to be uneconomical.

There is no doubt that coating weights of a wide range have proved perfectly satisfactory in production, and bearing in mind such factors as severity of deformation, tool forms, and economics one would suggest that a coating suitable for any extrusion could be selected from a range of 1.0 gm. per sq. ft. to 2.5 gm. per sq. ft. and the most generally used range appears to be 1.0 to 1.5 gm. per sq. ft. In the light of considerable experience in the field of cold extrusion at the Royal Ordnance Factory, Birtley, Morgan finds 2.0 gm. per sq. ft. adequate, and points out that coatings as heavy as 4.5 gm. per sq. ft. have been tried and have shown no improvement, and some evidence of inadequate lubrication has been noted with coatings of lower weights(8).

McKenzie and Rodger have studied the effect of zinc phosphate coating weights on extrusion pressures, covering a range from 250 mg. per sq. ft. to 3.0 gm. per sq. ft. It was found that the total variation in pressure required to extrude slugs treated over this range of coating weights was only 5 per cent and this was within the limits of reproducibility of the tests. They concluded therefore that tenacity and uniformity were more important than thickness or weight of coating. They noted also that no difference in surface finish was detectable in the finished extrusion, regardless of the coating weight(9).

While coating adherence is of supreme importance it is obviously desirable in large-scale production to also have some excess of coating over the minimum necessary to obtain a low extrusion load. This is some safeguard against variations in processing conditions, and will be beneficial in ensuring a reasonable tool life, assuming other factors to be correct. Recently very successful results have been obtained from zinc phosphate coatings of approximately 1.0 gm. per sq. ft. (Range 800 to 1,200 mg. per sq. ft.) Such coatings are produced from solutions operating completely free from dissolved ferrous iron (*see* reaction iv). This results in a relatively finer crystal structure despite prior acid pickling, and the coating has extremely good adherence to the base metal. A coating so produced contains the highest possible proportion of zinc tertiary phosphate. The effect of varying propor-

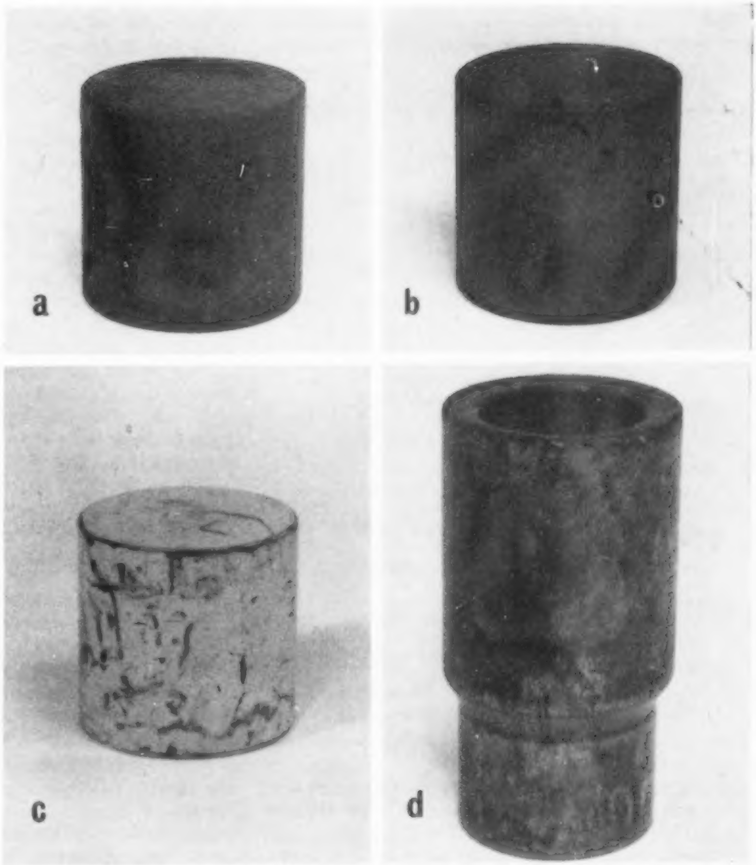


Fig. 2.—This shows (a) a steel slug in the heat-treated condition, (b) after pickling and phosphating, (c) after lubrication and (d) the extruded component

[*Courtesy of the Royal Ordnance Factory*

tions of ferrous iron in the phosphating bath on the composition of the coating deposited can be seen from Table I, while Fig. 3 shows the stages in which a component is formed with the aid of the coating obtained from such an "iron-free" solution.

TABLE I—*Variations in phosphate coating composition, obtained from iron-free and iron-containing solutions*

Analysis of phosphate coating	Fe'' free phosphating bath	Phosphating bath containing 0.43 per cent Fe''
Per cent Zn	34.2	27.5
Per cent Fe''	7.1	10.4
Per cent PO_4	42.1	40.0

On two components, direct comparisons were made by extruding slugs with a phosphate coating of 2.5 gm. per sq. ft. and then extruding similar slugs on which the coating was 1.0 gm. per sq. ft. The first component so tested was a cup formed by backward extrusion, the reduction of area being 69.2 per cent and the material mild steel. With the heavier coating, the average press load for the run was 203.3 tons and with the lighter coating 202.5 tons, there being no noticeable difference in the appearance of the extruded cups. At a different plant, another backward extrusion was carried out, the press loads in this case being 60.6 and 60.9 tons respectively. Within the limits of experimental error, in these cases there was obviously nothing to be gained by increasing coating weight over a nominal 1.0 gm. per sq. ft.

Successful extrusions have also been carried out without a pickling operation prior to phosphating. In such cases the coating weight obtained is only in the region of 600 mg. per sq. ft. but present indications are that tool life has not suffered because of this.

Lubricant

Various tests have been devised in an endeavour to determine the best lubricant for use under steel cold-extrusion conditions. In one such test zinc phosphate coated steel panels impregnated with various lubricants were compared with plain steel panels and a similar range of lubricants. The phosphate coatings were of 2.3 gm. per sq. ft. and

TABLE II—*Coefficients of friction (μ) for sulphonated tallow and sodium stearate on plain and phosphated steel under varying conditions*

Unit Pressure (lb. per sq. in.)	Lubricant System	μ
1,250	Plain steel + sulphonated tallow	2.7
	Plain steel + sodium stearate	1.8
	Phosphated steel + sulphonated tallow	0.9
	Phosphated steel + sodium stearate	0.6
2,500	Plain steel + sulphonated tallow	1.9
	Plain steel + sodium stearate	0.4
	Phosphated steel + sulphonated tallow	0.9
	Phosphated steel + sodium stearate	0.25
5,000	Plain steel + sulphonated tallow	1.8
	Plain steel + sodium stearate	1.8
	Phosphated steel + sulphonated tallow	0.65
	Phosphated steel + sodium stearate	0.55
12,500	Plain steel + sulphonated tallow	0.9
	Plain steel + sodium stearate	0.9
	Phosphated steel + sulphonated tallow	0.5
	Phosphated steel + sodium stearate	0.25

the coefficient of friction (μ) was determined at unit pressures ranging from 1,250 to 12,500 lb. per sq. in. (It should be noted that the highest unit pressures used in these tests were only approximately one fortieth of those which might well be experienced in actual extrusion operations. The difficulty of synthesising actual extrusion conditions in tests of coefficients of friction is, of course, the great weakness of such tests.) The results obtained in this series of determinations, for two well-tried lubricants, sulphonated tallow and sodium stearate, are shown in Table II. In these tests the samples were moving at speeds of approximately 0.3 to 0.5 inches per minute.

Many other tests have been carried out using the same general principles, and some of the lubricants tested, and actually used for extrusion have included rape oil, wool grease, palm oil, tallow and soap solutions. In 1949 Durer referred to "high-viscosity hydro-carbon oils, beef tallow and the like, frequently mixed with graphite" as being the lubricants used for the cold extrusion of steel([5]), while Fischer in 1953 suggested the use of lubricants containing fatty acid, whose (re)action could be increased by the introduction of sulphur compounds([11]). Overath more nearly forecast current technique when he suggested sodium, potassium, resin or naphthene soap emulsions, containing also some free fatty acid([12]).

Reference has been made to the reaction which takes place between the zinc phosphate coating and certain types of lubricant, and it is significant that virtually all the cold extrusion of steel now being carried out on a production scale uses a zinc phosphate coating in conjunction with a highly reactive stearate-based lubricant, to ensure the maximum formation of zinc soap.

It is believed that only the soaps of the alkali metals and of a few organic bases allow metathesis to take place between the lubricant and the coating, and experiments show that stearates and palmitates exhibit a more favourable behaviour in this respect

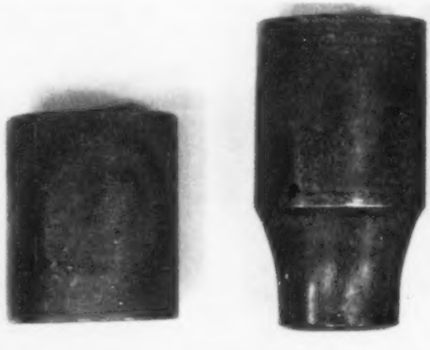


Fig. 3.—A brake master cylinder produced by cold extrusion in two stages, as shown. After annealing and pickling the slug and the first-stage extrusion, are phosphate coated in a zinc phosphate solution which operates in the ferrous-iron-free condition. A reactive stearate lubricant is then applied

Courtesy of Aero Heat Treatments Ltd.

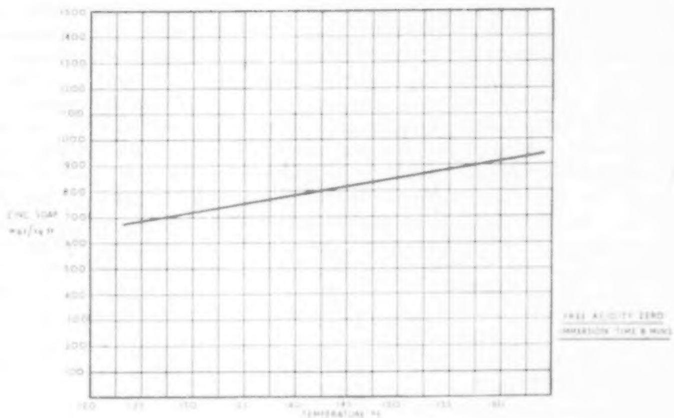


Fig. 4.—A graph showing the relationship between the degree of reaction and the lubricant temperature, using a reactive stearate lubricant on a zinc phosphated surface. Free acidity of the lubricant and immersion time were constant

than do soaps with smaller molecules. It is known that some chemical bonding takes place when phosphate-coated components are immersed in solutions of polar compounds containing the sulphonic group, such as sulphonated tallow, and, as mentioned above, such lubricants have in fact been employed.

In the case of pure hydrocarbons, these appear to be attached to the phosphated steel purely because of the excellent wettability of the coating. This probably accounts for their relatively poor film strength characteristics, and as far as is known such lubricants are not in use for cold steel extrusion.

Experimental evidence is available to show the extent to which hydrophobic metallic soaps are formed when phosphate-coated steel is introduced into solutions of alkali-metal soaps, and the following table shows typical results obtained on steel panels. These panels were treated in the normal sequence of operations used for steel components prior to extrusion. The different components of the lubricant " sandwich " so formed are fractionated analytically as follows :—

(i) The water-soluble sodium soaps are removed by careful washing with warm water.

(ii) The hydrophobic zinc soap is removed by a suitable mixture of solvents.

(iii) The residual phosphate coating is determined by one of the methods mentioned earlier.

The accurate determination of the various fractions of the lubricant film calls for a specialized technique. However, the problems encountered have been overcome by suitable laboratory techniques and Table III shows typical fractions determined by these methods.

The degree of combination which will take place between the coating and the lubricant is considerably influenced by the lubricant temperature and

TABLE III—*Typical result of a fractional analysis of the lubricant film on a slug prepared for cold extrusion. Also shown is the weight of soap deposited on a plain steel component without phosphate coating, but otherwise lubricated under identical conditions*

	Phosphate-coated Steel (mg. per sq. ft.)	Plain Steel (mg. per sq. ft.)
Water-soluble Soap.	270	230
Reacted Metal Soaps.	540	Nil
Residual Phosphate Coating.	1,080	Nil

the pH value of the solution. Obviously work must be allowed to remain in the lubricant until the reaction has achieved a suitable level. With improvements in techniques enabling the degree of reaction to be measured with considerable accuracy much work is currently being carried out to determine the optimum reaction conditions for soap type lubricants.

Figs. 4 and 5 show the effect of temperature and of variations of free acidity on a typical proprietary lubricant applied to zinc phosphate coated steel.

From the foregoing it will be seen that to obtain the best possible lubricant film for use under conditions of very high unit pressures it is necessary to study all these effects and give them due consideration. In practice, these are factors which will have been very thoroughly investigated by the supplier of the coating chemicals and the lubricant, and it is well worth while, therefore, making every effort to see that these products are used under the conditions

recommended. To this end, it is proposed now, to describe in detail the different stages through which a steel slug will normally pass between annealing and its introduction to the extrusion press.

Processing Sequence

The term "chemically clean" has been used to denote the condition in which it is required to present the steel surface to the zinc phosphate solution. In this context this is meant to indicate a steel surface completely free from grease, rust or scale and, of course, normal shop soil. It is likely that work coming forward for extrusion will be contaminated with cutting oils, or if it has been annealed will carry some degree of heat-treatment scale. If black bar is the raw material then both will normally be present.

While on a well-planned production line there will be little opportunity for slugs to rust prior to the processing, the collection of some shop soil and possibly grease, when being handled and transported to the pretreatment plant is very likely.

In view of these considerations and also because an acid pickle is usually considered desirable, even on scale-free surfaces, to ensure that the coating weight deposited will not be unduly low, the following sequence of operations has become virtually standard for the treatment of slugs and part-formed components :—

(1) Alkali degrease. Hot alkali cleaner.
(2) Rinse. Cold running water.
(3) Acid pickle. Hot sulphuric or cold hydrochloric acid.
(4) Rinse. Cold running water.
(5) Rinse. Water, preferably hot.
(6) Zinc phosphate solution. Proprietary process—hot.
(7) Rinse. Cold running water.
(8) Conditioning rinse. Proprietary process—hot.
(9) Lubricate. A stearate-based material in hot solution.
(10) Dry off. Air drying is frequently adequate.

The requirements and precautions to be taken at each stage are these :

Stage 1—*ALKALI DEGREASING*

For degreasing one of the many alkali degreasing materials available is employed. These may be grouped into three main groups :—

(a) *Light-duty cleaners.* These are very often based upon condensed phosphates or other quite mildly alkaline salts with wetting agents and are intended for the removal of light oils, handling grease and soils which are not particularly tenacious.

(b) *Medium-duty cleaners.* Generally based on sodium metasilicate as the main source of hydroxyl ions. These are ideal general-purpose cleaners and are capable of tackling most of the oils and greases likely to be encountered in the field under discussion.

(c) *Heavy-duty cleaners.* These work with a much higher causticity than those mentioned above, and are particularly recommended for removing temporary corrosion protectives, such as those based on lanoline. The latter tend to polymerize and harden with the passage of time, and when stock reaches the stage where it is to be formed into slugs a very tenacious film may be present.

The final choice of cleaner, therefore, depends on the type of grease film which will be encountered on the particular material to be processed. In the interests of economics one would select a cleaner in group (a) or (b) providing it will be adequate for the task envisaged.

All immersion-type alkali cleaners work best at fairly high temperatures, generally 180° F. or higher. Recent developments have produced low-temperature alkali cleaners for use by the spray technique, but for the application under discussion, the added complications involved in installing spray cleaning equipment as opposed to simple tanks for immersion would not seem to be justified, merely to reduce the heat load and the heating costs of the cleaning stage.

The strength of the alkali cleaner is maintained at the recommended level by carrying out, at reasonable intervals, a simple titration against a standard acid. By reference to a chart or table, the required alkali addition can be immediately calculated.

A correctly designed alkali degreasing tank would employ a weir-type overflow so that any oil layer at the top of the tank is virtually continuously flowed over the weir, avoiding the pick-up of oil as the work is removed from the tank.

Stage 2—*WATER RINSING*

After degreasing work should be washed in clean cold water, to avoid carry-over of alkali into the acid pickling section. It is strongly recommended that there should be a continuous water flow through this rinsing stage.

Stage 3—*ACID PICKLING*

For the acid pickling stage hot sulphuric acid, usually used at a strength of 10 to 15 per cent and a temperature in the region of 170° F. generally seems to be favoured. However, some companies prefer to use cold hydrochloric acid pickling and there is no evidence that the choice of which of these acids is used influences the ultimate coating to any material extent. On some black bar stock, and also on certain low-alloy steels, the scale is best removed by the use of inhibited cold 50 per cent hydrochloric acid.

If the plant is not of the automatic variety, it is possible that work will be allowed to remain in the acid for unduly long periods resulting in undesirable over-pickling, and in these conditions the use of an inhibitor in the acid is strongly recommended.

Proprietary pickles have been marketed which attack the base metal very viciously, and their effect is to produce unduly coarse phosphate coatings of very high coating weights. These very heavy coatings as previously noted, have been found to offer no advantages in the ultimate extrusion operation, but the economics of the pickling and phosphating operations are, of course, affected adversely. Additionally, these acid mixtures cannot be satisfactorily inhibited.

In addition to controlling the strength of acid pickles it is desirable that the ferrous iron content of the bath is regularly determined, as the efficiency of the pickle decreases as the ferrous iron content builds up. By such iron determinations it is possible to decide when to discard the pickle liquor, without waiting for efficiency to fall below acceptable limits. On a typical plant hot sulphuric acid is employed and is discarded when the iron concentration reaches 5 per cent.

Stage 4—*WATER RINSING*

The carry-over of pickling liquors into phosphating solutions is definitely to be avoided, as far as is practicable. Acid carried into the phosphating tank reacts with zinc tertiary phosphate present in the sludge layer, producing zinc primary phosphate and zinc sulphate or chloride, depending upon the nature of the pickle in use.

(i) $Zn_3(PO_4)_2 + 2H_2SO_4 \longrightarrow Zn\ (H_2PO_4)_2 + 2ZnSO_4$,

(ii) $Zn_3(PO_4)_2 + 4HCl \longrightarrow Zn\ (H_2PO_4)_2 + 2ZnCl_2$.

This zinc sulphate or zinc chloride contributes to the apparent strength of the working solution (the solution pointage—*see* below) so that at a constant strength (pointage) there is an increase in zinc and sulphate (or chloride), with a corresponding decrease in phosphate content. Slight traces of acid carry-over are compensated for by the routine cleaning out operations, normally carried out on any phosphating plant with the inevitable loss of some working solution. However, in extreme cases sufficient acid is carried forward to dissolve all the zinc phosphate in the sludge. In such a case, the free acidity of the solution will commence to rise, with deterioration in processing results, and complete discarding of the solution will probably become necessary. Fortunately this extreme condition is very rarely encountered in practice.

A highly contaminated rinse after pickling is also detrimental. If the contamination is largely due to acid, the effects noted above will be found. The contamination is most commonly largely ferrous salts, and input of these into the processing solution will result in undue consumption of both accelerators and phosphate. The work can, however, be contaminated with highly reactive ferric compounds resulting either from oxidation of the ferrous compounds, or from incipient rusting of the work, due to excessive rinsing dwell. The effect of this is to precipitate phosphate as ferric phosphate with the result of excessive consumption and unbalancing of the solution.

The above effects are overcome by adequately rinsing in clean water after the acid pickling stage. Immediately after pickling, work should be thoroughly rinsed in clean flowing cold water, and subsequently again in Stage 5.

Stage 5—*WATER RINSING*

Further clean water washing is carried out. There should be no undue delay at the rinse stages. If this second rinse is operated hot it enables the work to pass on to the subsequent phosphating stage at approximately working temperature.

To ensure that acid carry-over is not taking place it is advisable to carry out routine contamination checks on this rinse tank. This is very simply done by titrating a 50 ml. sample of the rinse water with O.1N caustic soda using phenolphthalein as the indicator. It is considered that contamination figures of less than 1.5 ml. 0.1N NaOH are not likely to be harmful.

Stage 6—*PHOSPHATE COATING*

For reasons already stated the type of solution employed in this, the phosphate-coating stage, will be a proprietary zinc-phosphate process. It may be one designed to work with a small ferrous iron content in which case the only chemical control necessary is that of total acid determination. This is carried out by a titration similar to the one mentioned above, and if the titration is performed on a 10-ml. sample and the standard alkali used is decinormal, the number of millilitres of standard alkali required is known as the pointage. Solutions used for the pretreatment of components for cold extrusion normally work at pointages ranging from 35 to 70. In practice, to avoid an unnecessarily large titration it is usual to take a smaller solution sample than 10 ml. or to use a stronger alkali than decinormal, the titration figure being converted to the recognized pointage by a suitable factor.

Solutions operated in the ferrous-iron-free condition are usually so maintained by means of the presence of free nitrite in the solution. High-strength nitrate accelerated solutions frequently generate sufficient nitrite within themselves to maintain themselves completely ferrous iron free:—

$$NO_3 + 2H \longrightarrow NO_2 + H_2O.$$

However, from time to time it is may be necessary to make separate additions of small quantities of sodium nitrite. A quick check on whether or not free nitrite is present in the solution can very simply be made by inserting a starch/potassium iodide indicator paper. If free nitrite is present the paper will turn blue; if it remains white, the absence of free nitrite is indicated, and ferrous iron is then probably present in the solution. A

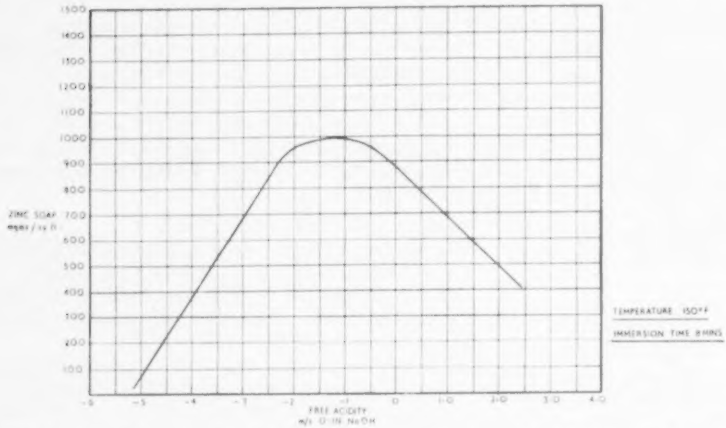


Fig. 5.—Again using a reactive stearate lubricant on a zinc phosphated surface, this graph shows reactivity against free acidity (pH), temperature and immersion time being constant

small addition of sodium nitrite solution normally returns the processing bath to the ferrous-iron-free condition. The amount of free nitrite present can readily be determined by means of a titration against a standard solution of potassium permanganate, the test sample being acidified with 50 per cent sulphuric acid, or a phosphoric/sulphuric acid mixture.

It should be noted, however, that ferrous iron can also be titrated with potassium permanganate in acid solution. No confusion should occur from this, however, if it is realized that the presence of nitrite can be confirmed by the starch/potassium iodide paper, and under these conditions the titration must be due to the nitrite present. A more accurate determination can be made by titrating two identical samples to the second of which is added urea. This reacts with any free nitrite :—

$CO(NH_2)_2 + 2HNO_2 \longrightarrow CO_2 + 2N_2 + 3H_2O.$

One would expect this second titration to be zero, and under ideal conditions, *i.e.*, with a new phosphating solution, this will be so. However, the presence of organic impurities can cause there to be a small blank titration with the potassium permanganate. For an accurate determination of the nitrite present, therefore, the second titration is subtracted from the first.

If ferrous iron is present both titrations will be the same and be due to ferrous iron plus organic impurities.

While present-day techniques make it possible to deposit crystalline zinc phosphate coatings from temperatures as low as the ambient temperature, the type of coating best suited for extrusion work is obtained from solutions working at temperatures between 180° F. and 200° F.

All zinc phosphate solutions produce, as a necessary by-product of their reaction, a sludge which in a properly designed plant settles to the bottom of the process tank and is part of the self-regulating mechanism whereby free acidity is maintained constant even when some input of pickling acid occurs. The plant should be so designed that the area at the bottom of the process tank is free from convection currents, thus permitting the sludge to settle easily, and not be disturbed during processing. Typical methods of steam and gas heating phosphating tanks are shown in Fig. 5.

When it becomes necessary to clean out a process tank, the clear liquid above the sludge layer is pumped over to an adjacent rinse tank, previously emptied, and the sludge is removed. The phosphating solution is then returned to the process tank, the working level adjusted, and after testing, chemical added to restore the strength of the solution.

Suitable paper-band filters are now available which will continuously filter a phosphating solution. It is necessary to use, in conjunction with these, process tanks with conical bases, the angle of the cone being not less than 60 deg. so that the sludge formed in processing will fall freely. The sludge-containing solution is pumped to the band filter and allowed to return to the process tank by gravity, after passing through the filter.

Stage 7—*WATER RINSING*

After phosphating most of the surplus processing chemicals are washed from the surface in clean cold water. Again the rinse should be flowing to reduce to a minimum, contamination of subsequent stages of treatment.

Stage 8—*SURFACE-CONDITIONING RINSE*

It is normal to immerse the phosphate-coated steel in a conditioning rinse before lubrication. This operates at a similar *p*H to the lubricant itself and thus prevents variations occurring in the lubricant due to carry-over. It is claimed that, since the surface of the slug enters the lubricant wet from this rinse that the maximum possible reaction

is obtained in the lubricant stage. It is certain that the use of such rinses, neutralizing as they do, any carry-over of acidity from the phosphating solution, prolong the useful life of the lubricant considerably.

Stage 9—*LUBRICATING*

Since the use of sodium fatty-acid soaps is virtually standard practice as lubricants for the cold extrusion of steel, the subsequent comments are based on the assumption that the lubricant used will be of this type.

Four variables are to be considered in using the lubricant.

(a) Concentration.
(b) Free Acidity or *p*H.
(c) Temperature.
(d) Immersion time.

Fat contents of between 3 per cent and 6 per cent by weight have been found to be the most successful for extrusion purposes, the exact strength for a particular application usually being determined experimentally, on the job in question. Inadequate lubricant films will obviously result in uneconomic tool life, while as previously mentioned, a considerable excess of lubricant can prevent the component from being accurately formed. It is unlikely that difficulties of this nature will be experienced in the strength range quoted.

Six per cent, by weight, of fatty acid will probably not be represented by the equivalent weight of a proprietary lubricant, as the use of straight sodium stearate, or a sodium stearate/palmitate/oleate blend is generally considered inferior in reactivity to a lubricant containing buffer chemicals designed to maintain a constant *p*H. Rust-inhibiting materials are also commonly included in the composition of the lubricant. For these reasons proprietary lubricants will often be supplied with recommendations for use at strengths of over 6 per cent by weight of the blended mixture.

Lubricant strength is usually determined by " cracking " a sample with sulphuric acid. The acidified sample is allowed to digest at elevated temperature for 30 to 60 minutes. An oily layer gradually forms at the top of the container which should be a specially designed graduated tube, or flask with a graduated neck. By means of this the amount of oily material produced from the sample can be measured and the lubricant strength calculated.

The importance of the *p*H value of the lubricant has been mentioned. As *p*H rises, *i.e.*, as the degree of alkalinity increases, the reaction between coating and lubricant is accelerated in the direction of zinc soap formation; however, above a certain level of *p*H deposition of the metallic soap is prevented, while the solution will begin to attack the coating.

Accurate determinations of the *p*H of soap solutions by means of *p*H indicator papers is not practicable in the case of soap solutions. If available, of course, a *p*H meter can be employed. More usual, however, is the practice of determining the free acidity present in the lubricant solution by titrating a sample which has been boiled with an indicator, consisting of phenolphthalein in isopropanol, the sample being titrated against decinormal caustic soda. Obviously *p*H and free acidity are correlated.

Immersion time for reactive stearate-type lubricants is usually about five minutes. It is unlikely that the reaction

$$Zn_3(PO_4)_2 + 6C_{17}H_{35}COONa = 3(C_{17}H_{35}COO)_2Zn + 2Na_3PO_4$$

reaches equilibrium in this period, but the amount of reacted soap obtained is normally found to be satisfactory under these conditions. The lubricants normally employed are not sufficiently alkaline to have a stripping effect on the phosphate coating. However, this is not true in the case of oxalate coatings, which are used instead of phosphates for the coating of austenitic steels, and which have been used with some success for experiments in the cold extrusion of stainless steel[13].

Stage 10—*DRYING OF LUBRICANTS*

For the lubricant film to have the best pressure-film characteristics it is essential to dry off all surplus moisture. If the slugs are fairly heavy they will normally dry sufficiently from the heat retained therein. If forced drying is employed the temperature employed should not exceed 350° F. to ensure that the soap film is not harmed.

Pretreatment Plant

To carry out the sequence of operations required in production thought must obviously be given to the type of plant in which this can best be done. Many factors must be considered when planning this equipment, predominantly the following :—

(1) Number and weight of components to be treated in a given period.

(2) Type of components, *i.e.*, the variety to be handled in the plant, and their various shapes.

(3) Type of heating available.

(4) Degree of automation required.

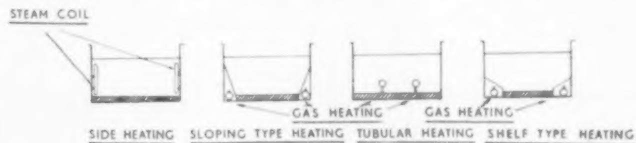
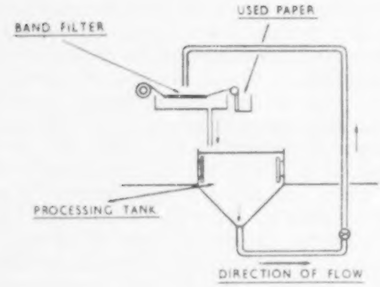


Fig. 6.—*Methods of heating phosphating tanks*



(5) Space available for installation.

(6) Possible future requirements.

(7) Capital cost.

Care should be taken when processing that there are no patches devoid of coating or lubricant, due to contact between components being treated and/or between components and the containers. If a simple basket is being used, work should be moved slightly every 2 to 3 minutes in the processing and lubricating stages to overcome this. Many plants are designed so that either continuous or intermittent movement of parts being treated takes place.

If cupped articles are to be treated, care must be taken to see that they fill and drain properly as they enter and leave each stage. Again, in many plants this requirement is catered for automatically. The following are some of the types of plant either in use, or under consideration, for the treatment of components prior to cold extrusion.

(a) *Simple Immersion Plant*

This consists of a row of suitably constructed tanks, usually with an overhead hoist to assist handling. Such a plant is ideal for the preparation of slugs during the development period, but once presses are tooled up for quantity production, its limitations are obvious. However, such a plant can be very flexible, merely by changing the type of basket, a wide variety of components can be treated, and the cost of this type of equipment is much lower than that of the more complicated types of plant.

Two points should be noted with regard to the work baskets used on such a set-up, or on any plant where baskets or jigs traverse through the full sequence of operations. They should be of a material which will resist the attack of the acid pickle, and will not affect or be affected by the phosphating solution. Second, the lubricant picked up by the work baskets or jigs must be removed before they are re-used. While this can be removed by alkali cleaners, they soon become saturated with the soap and lose efficiency. Special acid cleaners have been developed for this purpose. It may, therefore, be desirable to introduce such an acid cleaning stage, with a subsequent water rinse, into the line.

(b) *Tipping-basket Plants*

Such plants are ideally suited for components of say less than 4 oz. per piece in weight. Heavier

Fig. 7 (above).—The method used for the continuous filtration of phosphating solutions

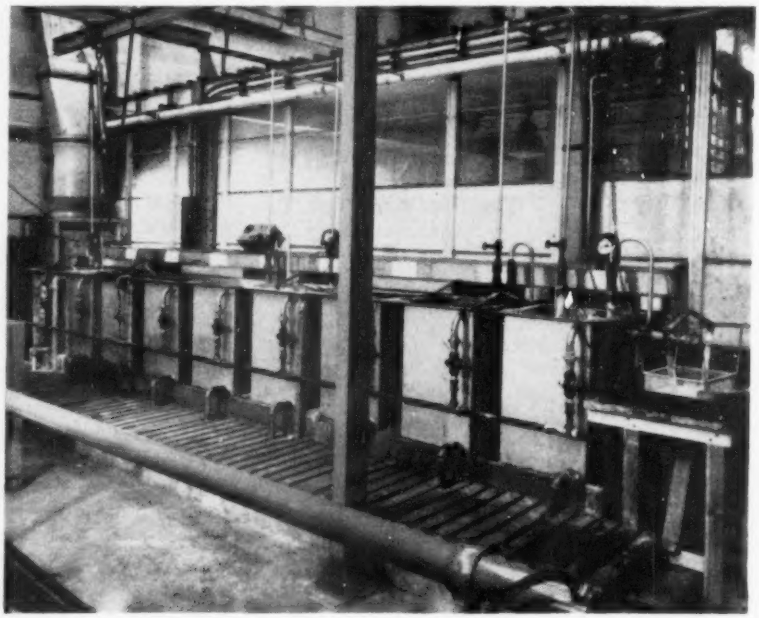


Fig. 8 (right).—A simple pilot-scale plant used for preparing parts for cold extrusion. The stages in this plant are, from left to right:
(1) *Alkali clean (Pyroclean No. 9).*
(2) *Water rinse.*
(3) *Sulphuric acid pickle.*
(4) and (5) *Water rinses.*
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(9) *Lubricant (Bonderlube 235).*

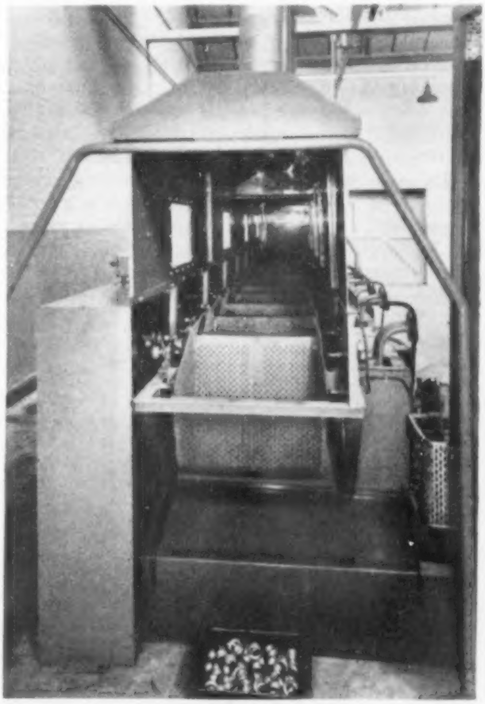
[*Courtesy of the British Motor Corporation.*

slugs may well be damaged as they are thrown forward from basket to basket as may be the work-baskets themselves. The principle of such a machine is simple. A line of tanks is arranged, with baskets pivoted at the top, in such a way that each basket is lifted in turn, commencing with the final stage, thus each basket in turn transfers its load to the next basket forward. Having fixed a cycle time the processing times are controlled by the number of baskets in any one tank, *e.g.*, for a 10-minute phosphating immersion, and a cycle time of $2\frac{1}{2}$ minutes, four baskets would be required in this stage.

Tipping-basket plants can be operated manually, power operated with manual control at each basket, or fully automatic. In the case of fully-automatic machines, baskets are invariably arranged to operate in banks to increase the productivity of the plant. Such plants are either electro-hydraulic or electro-pneumatic, the sequence being controlled by a timer and relays.

Plants of this type have the advantage that work-pieces have their position relative to each other, and to the baskets changed as they progress forward, and thus the problem of contact is largely overcome. However, as already stated, they are not considered suitable for heavy components because of the possibility of damage, both to the components and the baskets. Such plants are not suitable for deeply cupped articles, as a proportion of these would be bound to settle in the inverted position, when treatment of the inside would be prevented by the air-lock formed. Similarly, others would be thrown forward at each stage in such a position that they would not drain, and an unacceptable degree of carry-over from stage to stage would take place.

A useful point to note in connection with tipping-basket machines is that the baskets themselves are not transferred from one solution to another, therefore it is only necessary to use acid-proof equipment in the pickling and possibly phosphating sections; likewise, there is no need to incorporate a "desoaping" section for the work baskets.



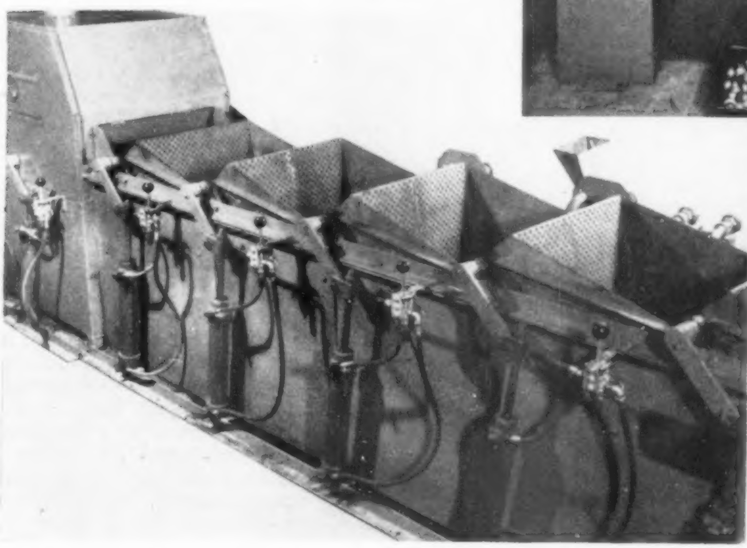
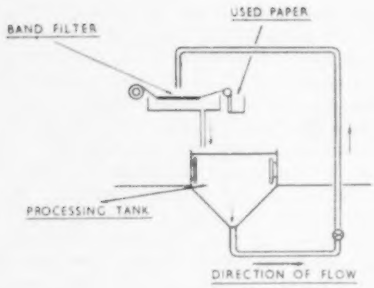


Fig. 9.—Two types of tipping basket plant:
(a) (above) Fully automatic, hydraulically operated
(b) (left) Semi-automatic, pneumatically operated
[*Courtesy: The Pyrene Co. Ltd.*



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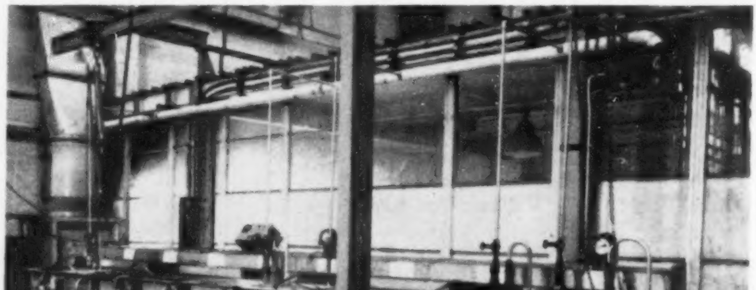

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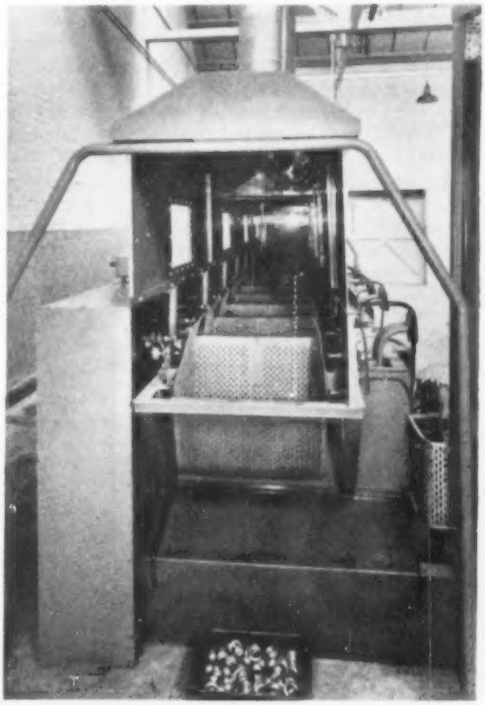

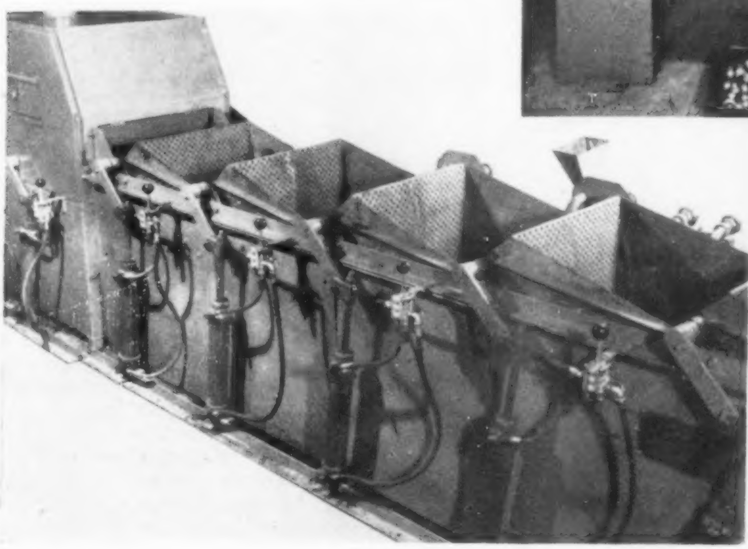

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[*Courtesy: The Pyrene Co. Ltd.*

(c) *Transfer-type Plants*

This type of plant is essentially a transfer-type plating machine adapted to the sequence of operations and treatment times necessary for the preparation of extrusion slugs. As with a simple immersion set-up some means of moving the work during the pickling, phosphating and lubricating operations is desirable to eliminate contact problems. One way in which this can be done is to employ baskets with lids, which rotate through 180 deg. half-way through the cycle time, and again immediately prior to transfer.

Transfer-type equipment is reasonably compact, as the plant is of a closed-circuit layout, and is fully automatic in operation ; by its very nature, however, it cannot be inexpensive in view of the lifting, transferring and timing equipment which is involved.

(d) *Rotary-barrel Plants*

To overcome difficulties from contact and high drag-out from cupped components, slowly revolving barrels can be used to hold the work during processing and such barrels have proved extremely popular in Germany and America. In view of their low rotational speed (in the order of one revolution in four minutes) work is not damaged in processing. This type of barrel can be used in conjunction with simple immersion tanks, or as the work-carrier in a transfer-type plant such as that just described.

In America, the processing barrels are generally rotated by means of a compressed-air motor, driving the barrel through a small gear-box and a train of gears, all of which are carried on a substantial stainless-steel framework, the whole of this set-up being transferred from tank to tank. The air motor has infinitely-variable speed, so that the rotational speed of the barrel can, if required, be varied for different processes or different components.

In addition to the plants outlined, various other handling techniques are possible, such as a row of rotating drums in which work is progressed by an Archimedes screw feed from drum to drum. Yet another method of handling is to progress the work forward in a series of tilting chutes, each chute feeding a number of slugs into the appropriate tank. After processing the chute is raised to transfer the work to the next stage. Such a plant is suitable for cylindrical slugs but suffers from the disadvantage that the chutes must be " tailored " to a particular slug size.

Process tanks can be heated by steam, high-pressure hot water, gas, oil or, if necessary, by electricity ; however, when available steam or high-pressure hot water are easily the most suitable, as

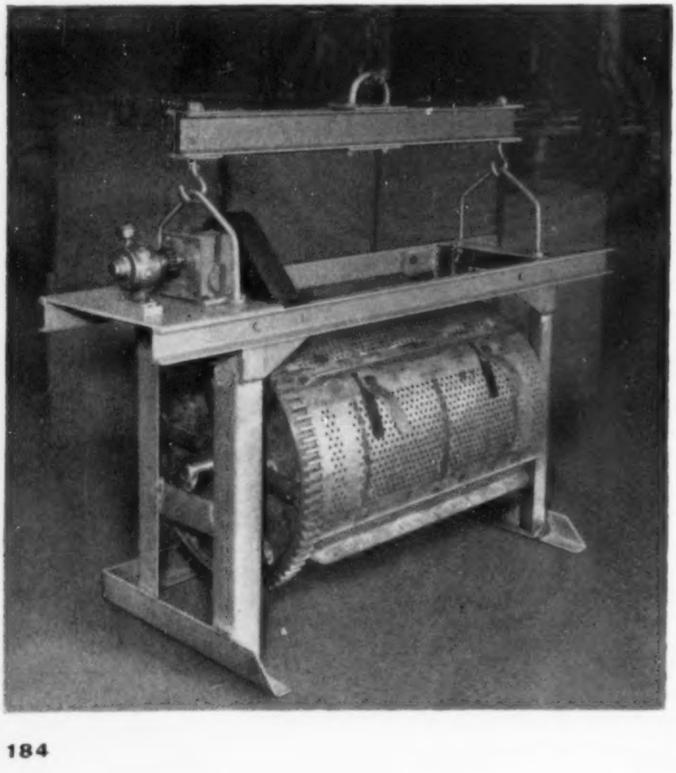

Fig. 10.—A barrel unit suitable for processing extrusion slugs. Such units are widely used in America and Germany, and the one shown is driven by a compressed air motor

[*Courtesy of Parker Rust Proof Company, Detroit, U.S.A.*

pickle tanks and phosphating tanks can then be lined with a suitable rubber or plastic material. The direct heating of pickle tanks raises problems of suitable material for their manufacture, although some of the more recently developed high-nickel alloys are reported to have excellent properties in conjunction with sulphuric acid at elevated temperatures.

Steam heating coils can be of mild steel in phosphating plants, but these tend to scale up heavily and have a somewhat limited life in high-strength solutions. Better is molybdenum-bearing stainless steel or certain high-nickel alloys, while the use of titanium shows great promise and coils of this material compare not unfavourably with stainless steel in price.

For acid pickles, lead-covered coils are generally used, but again, titanium or some of the special high-nickel alloys are well worthy of consideration.

From this it will be seen that plants are available which are capable of dealing with any project likely to materialize in the foreseeable future. The ultimate choice of the type of equipment to be installed must rest with the user, having paid due regard to the considerations mentioned herein.

Other Developments

While most cold-extrusion development has been concentrated on the forming of mild steel, work has also been done with alloy steels. Low alloys can be phosphate coated, although in general the coating weight produced tends to be somewhat lower than on mild steel. Some very successful results have been seen on nickel/chrome/molybdenum alloy steels and in these cases no special technique other than that outlined was used for the lubrication.

The use of oxalate coatings for stainless steel has been briefly mentioned, and chemical-conversion coatings have been developed for titanium(14), zirconium(15) and beryllium(16) (17), for use in development work in cold and "warm" extrusion of these metals.

Conclusion

Consideration in detail of the requirements for pickling, phosphating and lubricating steel prior to extrusion may make the task seem formidable. In fact this is not so. These requirements are now well understood, and although there will almost certainly be great advances in the technique of lubrication in the future, methods and materials are available, and in everyday use which provide a virtually foolproof lubricant system. Much of what has been written here concerns mainly the supplier of phosphating solutions and lubricants and most of the points raised here will have been considered when materials are formulated, operating instructions prepared and recommendations made for their use. A close liaison is also maintained between chemical manufacturers and plant suppliers so that each in turn can make full use of developments in the others' field.

A considerable amount of research and development is being concentrated on coating/lubricant systems to aid metal forming, and in the forefront of this work comes research into the best methods of lubricating steel for subsequent cold extrusion. The details given in this paper are available as a result of such research carried out to date, and considerable field experience. In this connexion the author gratefully acknowledges the assistance given to him by colleagues in the Technical Sales and Service Departments and the Laboratories of the Metal Finishing Division of The Pyrene Co. Ltd., and for permission to publish details and photographs supplied by this company and also by the following: The Royal Ordnance Factory, Birtley; Aero Heat Treatments Ltd.; C.A.V. Ltd.; British Motor Corporation.

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(14) British Patents No. BP. 823928, BP. 826912, BPA. 843054.

(15) British Patents No. BP. 812080, BPA. 843054.

(16) British Patents No. BPA. 843054, BPA. 836062

(17) Patent pending.

DISCUSSION

Mr. R. F. Drysdale (Walterisation Co. Ltd.) referring to Mr. James's paper, said that his own company had had a parallel experience and he would not differ on any of the broad principles expressed. Mr. James had said, however, that coating weight for extrusion purposes was a question on which widely differing opinions were held and he had quoted the fact that two other papers referred to the use of coating weights of 3,000 mg. per sq. ft. and over in the United States. His own organization had actually had demand for coatings in excess of that figure for extrusion purposes, where the percentage deformation was extremely high, and had been told by the users that a lower coating weight produced an inferior finish and demanded a greater pressure in the press.

It was only fair to say that these demands had

come from projects which had started some years ago, and it was also possibly true to say that at that time, in the first flush of enthusiasm, attempts were being made to do much more than they were today.

Mr. Okell in his paper had referred to this tendency. He would certainly agree that at present new demands were not being made for very heavy coating weights. At the same time, he could not help feeling that there was a possibility that, as techniques improved and tool design improved also, the more severe deformations that had been attempted a few years ago would be carried out and then heavier coatings might be required.

The heavier coatings could be produced by the technique that Mr. James had mentioned, although it probably meant a very high-strength bath and a rather longer treatment time than users would desire. There was one method of doing this and that was the use of special pickling solutions, although in that case he would prefer to regard them as surface conditioning solutions rather than pickling solutions.

Mr. James had been rather caustic in his comment on proprietary pickles, and with this he would have no quarrel, but he had also referred to them as mixed-acid pickles and, in his own experience, it did not necessarily follow that these treatment solutions were subject to all the disadvantages that Mr. James had listed. It was certainly true that they required much more careful control than the straight acid pickles. It was also true that, because they were more active, they were a little more expensive to use, but this could be offset by the fact that they allowed lower point strength and shorter immersion times. He would certainly not agree that they all produced the coarsely crystalline structure mentioned. As an example, he had actually substituted, in commercial practice, on at least one occasion, the use of a mixed-acid conditioning solution followed by the highly accelerated phosphate coating process to which Mr. James had referred as giving the fine crystalline structure, for straight acid pickling of the zinc-iron coating, in order to achieve a finer crystal structure.

Mr. James said that he was rather glad that Mr. Drysdale had raised these points. He had mentioned two jobs on which he had had a requirement for a very heavy phosphate coating. He was himself familiar with the jobs referred to. One of them was, in no sense, an extrusion, but a drawing operation.

Mr. Drysdale said that he was referring to two actual extrusions.

Effect of Increased Coating Weight

Mr. James said that perhaps "coarse crystal structure" was a slightly harsh way of describing it, but if a heavy phosphate coating was required then it was necessary to have a large crystal. This had been borne out quite independently in another paper (presented by the Production Engineering Research Association). He was also interested in the fact that work done at National Engineering Laboratories, PERA and the Royal Ordnance Factory, in investigating the effect of heavy coating weights, had indicated that in no case was there any reduction in the extrusion load obtained by increasing the coating weight. Indeed, N.E.L. had found every indication that extrusion load fell if the coating weight was reduced. Obviously, there was a limit to how far it was possible to pursue this line of thought because if a component was satisfactorily extruded with a coating weight of 250 mg. per sq. ft., it would not be safe to turn such a coating loose on industry, and Mr. Drysdale would be the first to agree that there must be a reasonable safety factor. He agreed with him that there would be developments in metal forming which would put heavier and heavier burdens on lubrication, but his own personal opinion, and he thought also that of his colleagues, was that the answer to this would not be in heavier phosphate coatings, but in better reaction and better control of reaction between lubricant and coating.

Special Pickles

He would mention one other point on special pickles and he apologized if he had referred to them as mixed acids. In this he might not have been quite correct, but he thought that in essence the result was the same. Mr. Drysdale had rightly mentioned the increased degree of control necessary. He was of the opinion that an increase in chemical control was not a good thing if it could be avoided. It also introduced problems from the plant manufacturer's point of view in that he had some rather unpleasant material to try to contain. There were many ways of producing heavy phosphate coatings other than the use of such pickles, and they did not always entail long immersion periods, or even having iron phosphate present in solution.

Mr. D. A. Oliver (B.S.A. Group Research Centre) said that he had not had an opportunity of reading every word of Mr. James's paper, but would ask whether there was any advantage in "gilding the lily" and perhaps having a phosphate coating of preferred thickness and then probably an oil and graphite or oil and molybdenum disulphide impregnated material on top of that. He would also ask whether the exact method of the lubrication of the phosphate coating was understood and whether it could be still further extended in its advantages by further additional lubricating systems that in certain circumstances had some advantage.

Mr. James replied that the mechanism of the lubricant system was fully understood, but not perhaps its behaviour under conditions of extrusion. He thought that the mechanism was certainly a

question of deposition of coating, reaction of part of the coating with lubricant and finally, a layer of unreacted lubricant.

The suggestion for using oil and graphite on the coating prior to the application of the reactive lubricant did not seem to him to be practicable. Having impregnated the coating with graphite, one would then prevent reaction between the lubricant and the coating, and this was essential. A certain number of experiments of a kind had been conducted by people from time to time who had had difficulty with an operation and had added molybdenum disulphide as an auxiliary lubricant to the standard lubricant system. He thought that in almost every case it had been found that modification of tool design had proved the auxiliary lubricant to be unnecessary.

Mr. Morgan (R.O.F., Birtley) said that it was true, of course, that they were now in the field of phosphate coatings requiring probably about ten tanks to apply. That was a very large plant. In the film shown by Mr. Okell extrusion was probably being carried out with a manganese phosphate solution. He knew that a start had been made with this, accompanied by only a wet-soap dip. The film showed what appeared to be the manufacture of a front suspension member for motor-cycles at a speed of about three strokes a minute. It would seem that there was a trend away from the simplicity practised in those days. Was this caused by the high speed of manufacture? If there was a slow speed of manufacture, would it be possible to go back to a simple manganese phosphate coat with an ordinary wet-soap lubricant? In the ten-tank system it was necessary first to de-grease and then follow this with acid pickle, etc. If a Wheelabrator where the components were put in by the hundred was used so that the scale was all taken off, would it not be possible to eliminate two tanks—the de-grease and the acid pickle to get rid of the scale? It would then be possible to go straight into the phosphate treatment.

Mr. James said that there was no way of knowing, from the film, really whether a manganese or zinc phosphate treatment was being used. Certainly, the original experiments had used manganese phosphates, but a change was quickly made to zinc phosphate. In regard to the use of soap, from the white appearance of the slugs he would say that that almost certainly they had been treated with Bonderlube.

Drying Lubricant Film

From the film, there appeared to be no attempt to dry off after dipping. There was little doubt that the film strength characteristics were greatly improved by the lubricant being allowed to dry completely. Mr. Morgan had suggested reducing the number of tanks below ten, but it had to be remembered that alkaline de-greasing was not necessary if it was possible to guarantee that there would be a clean heat-treated slug. This would eliminate two of the ten tanks straight away. Since washing was only done after acid pickling and phosphating, one rinsing could be eliminated in each case, but he knew from bitter experience that even with two rinses after acid pickling, the amount of sulphuric and hydrochloric acid that could find its way into a phosphate was not inconsiderable. The number of people in his experience who had been trying to phosphate with zinc sulphate or zinc chloride solutions because of this gave food for thought.

In regard to producing a satisfactory coating on a shot-blasted surface, it was necessary to think of coating weight. This was definitely lower than with an acid pickled surface—often below the safe minimum figure, and considerably lower than those that Mr. Drysdale was recommending. On the other hand, he knew of at least one company where reasonably successful runs had been obtained without any acid pickling on a job where the coating requirement was obviously not very high.

Mr. Drysdale said that he was not recommending heavy coatings *ad lib*, but merely saying that there were certainly some instances where his organization had been asked for them. He would certainly agree that they were not being asked for now. Eventually there might be a return to them. There was actually an installation in being which was producing a 2-gm. coating weight on a shot-blast surface.

The Chairman (Mr. W. A. Johnson) said that he was always interested in the economics of the situation. If one had an adequate lubricant, qualitatively, did it much matter whether there was a 20 per cent excess? Did coating weight, within reasonable limits, matter very much from that point of view. Was it a matter of expense or merely of making a dirty mess?

Mr. James said that it was a little of each. If coating weight were increased by 20 per cent, so too would be the cost of the coating. In addition to the chemicals consumed in the coating, there was also a loss by way of mechanical drag-out. The "dirty mess" aspect was worth mentioning. Difficulty would be experienced with too heavy a phosphate and lubricant film because the surface coating tended to pack around the extrusion tools, which frequently needed cleaning. The work had to be stopped consistently to permit the tools to be cleaned.

Coefficient of Friction

Dr. Wallace said that in Table II of his paper Mr. James had quoted some extremely high values of coefficient of friction. The first he had given was 2.7. He wondered whether the decimal point had become misplaced?

Mr. JAMES replied that this was based on work carried out in America. The figure had certainly not been misplaced by him.

Dr. WALLACE said that these coefficients of friction could not possibly exist in an extrusion process because the material would shear on the surface when the shear stress reached the shear strength of the material. This gave a maximum possible coefficient of friction under dry conditions of about 0.5 and under extrusion conditions where the normal pressure was very high it would be much less.

Mr. JAMES said that the fact was mentioned that the tests were not carried out under extrusion conditions.

Dr. WALLACE said that someone might pick up this figure and try to apply it to cold extrusion. He would get very unrealistic values so far as calculated extrusion load was concerned.

Mr. JAMES said that this point had been made in the paper: that it was virtually impossible to carry out coefficient-of-friction determinations under actual extrusion conditions with any of the test arrangements available at present. The only true test was an extrusion.

Mr. DREWERY said that when the National Engineering Laboratory extruded a slug the lubricated surface was then spread over the inside of a can or the outside of a rod. Could the author give figures that might help in the design of a weight of coating in milligrams per square foot, and also the area over which that could be successfully spread? In the case of a backward can extrusion one spread the top surface of the slug all over the inside of the tube. How far could one stretch the area of lubricant over the inside of a product?

Mr. JAMES said that no one had extruded a rod or a can sufficiently far to stretch the coating until it broke down.

Stearate Coatings

Dr. WALLACE asked whether in using stearate coating, the author found that a coating weight was dependent on the speed at which one was going to extrude? It was his own experience that this type of coating had a pronounced speed effect. The higher the speed the more breakdown appeared on coating, and the higher was the coefficient of friction. To avoid this, did he recommend higher coating weight for high-speed extrusion as compared with low-speed work?

Mr. JAMES said that it had not been found necessary. In the speed range being used for extrusions in America, France, Germany or this country, a roughly standard lubricant system had been found adequate to deal with all punch speeds encountered.

Mr. SPIKES (Joseph Lucas Ltd.) said that people were talking about coatings as if they were the only thing that mattered. There was ample evidence to show, in his own organization, that the way in which control was effected on the temperature of the bar, the pickle and a number of other things mattered as well. Using the same chemicals and same coating weight, there were different extrusion forces and tool forces. The author's paper had produced the wrong impression if it had made people think that coatings were the only things that mattered.

Mr. JAMES said that, probably, there had been an over-emphasis on coating weight as a result of some of the discussion, but he did not think that the point he had made in introducing the paper had been forgotten—that the way in which the solutions were applied was extremely important. He did not know how to get people to accept this from the suppliers. They knew from bitter experience that although they might introduce solutions and lubricants that would work perfectly satisfactorily under a fairly wide range of operating conditions, a large number of users would manage to get well outside that range, and then satisfactory results could not be expected. He did not know the simple answer to this.

Testing Coatings

Mr. OKELL said that his organization's method of trying a variety of coatings was, first, to look at them, second, to scratch them with the thumb-nail, third, to run the thumb over the coating plus lubricant, and fourth, to put them in the press. The last test could be catastrophic. Was there any chance that the lubricant suppliers would be able to provide a test that was simple, reliable and capable of being put into operation in the press shop?

As to the points raised by Mr. Morgan, the lubricant system shown in the film had been zinc phosphate plus Bonderlube. The liquid lubricant had been employed in a drawing operation, or rather an ironing operation in which an attempt was made to give something like 30 per cent reduction in wall thickness. This operation had been giving trouble. It had not been the fault of the Bonderlube, but probably of the method of treatment. A technician from Neumeyer A.G. was consulted and he, in the end, had gone off in desperation to a little shop round the corner and bought half-a-pound of toilet soap. With this he had proceeded to show what a lubricant coating should look like and how it should draw—with every success.

Mr. JAMES said that he took cognizance of the request for a test that would show the adequacy of phosphate coating without the necessity to put the slug into an extrusion press. He hoped that his laboratory colleagues were listening and would also take due note. Perhaps Mr. Okell was a little harsh in regard to visual testing because he felt quite sure that with the experience that existed at Forgings and Presswork, one would rarely put components in the press that were not reasonably satisfactorily phosphate coated and lubricated. It

was possible visually to get an extremely good idea of the quality of the lubrication. The trouble lay not with people who were experienced, but very often with the plant operator himself who had not been sufficiently educated to carry out a certain amount of visual inspection. It was necessary, at the first sign of anything unusual, to stop and investigate it instead of carrying on and hoping that the unsatisfactory coating would be hidden by the lubricant and thus not noticed. He would agree that at the moment there was no overall test other than a visual test. Some idea of the quality could be gained by coating weight determinations, and lubricant weight determinations as well.

Differential Lubrication

Dr. WALLACE said that it appeared to be accepted that as much lubricant as possible was required to get the best result. This was not always the case, as had been recently shown in deep drawing, and there were reasons why it should apply in extrusion also. Had Mr. James any experience of the use of differential lubrication? In steel extrusion reductions were rather low, *e.g.*, 50 per cent to 70 per cent. It was possible to show, theoretically, that with the rather high reductions of 90 per cent plus, coupled with certain critical die shapes, the material would tend to shear within itself rather than slide along the surface, unless the coefficient of friction was less than about 0.95. In these conditions, it was preferable to keep the surfaces rough and hold the material there, permitting this internal slip.

Mr. JAMES replied that he was surprised anyone should think the discussion had indicated that the best method of lubrication was to put on as much as possible. If anything had come out of it, he would have thought that it was the reverse; that one should not do so with the object of getting the best possible extrusion.

As far as the differential lubrication was concerned, his organization had a certain amount of experience of differential coating weights. As regard rough tool surfaces, they had no experience at all. He assumed Dr. Wallace meant tool surfaces rather than slug surfaces, because if the latter were phosphate coated, obviously it would retain as much lubricant as any mechanical surface could ever hope to. He did not know what Mr. Morgan, who had rather strong ideas about tool surfaces, would think of the idea of having a rather rough surface as a method of increasing the area of reduction possible.

Mr. MORGAN said that he tried to effect the finest tool surface that could be obtained. The reference to the degree of lubrication, and how much could be used, recalled an experience with a high-strength aluminium extrusion. When too much lubricant had been put on the lubricant blistered the component and caused pinholes. It was plainly detrimental to have too much lubrication.

Mr. DREWERY said that Mr. James had briefly answered a question of his about the spread of the lubricant film, and the matter of breakdown. In Fig. 28 of Mr. Morgan's paper,* there was a curve which rose steeply because of the breakdown of a lubricant film, so it would appear that someone had in fact stretched such a film until it broke down.

Mr. JAMES said that, unless he was mistaken, this was not the reason. Mr. Morgan had been using a punch of unusual shape which resulted in the metal flowing from the inside of the component on to the surface, and unlubricated metal coming into contact with the tool. That was one of the reasons why it was necessary to use a flat-nosed punch.

Mr. L. R. HAWTIN said that, so far as differential lubrication was concerned, it was fairly common in other materials than steel to reduce lubrication, *e.g.*, on the rear face of a billet that was being cold-extruded. He had seen annular grooves machined in the billet-contacting face of the punch in order to minimize radial flow, as a means of delaying the onset of piping. Therefore, his answer was that it was done, but he did not know whether it was in steel practice.

Mr. JAMES said that it was not, to his knowledge.

Mr. H. T. HUNNISETT (Cold Precision Forgings (D &C) Ltd.) said that, in regard to the question of the spread of lubricant, it would have been interesting to have seen a photograph of the crystal formation after extrusion. He had been looking at an extruded surface on the top of an upset cold-headed, cold-forged bar magnified one hundred times. To the naked eye it looked perfectly in order, and a pale grey colour, but under the microscope it appeared to consist of isolated crystals of phosphate coating in a matrix of bright steel. He would like to know whether the author considered this the normal pattern of an extruded surface under a microscope.

Mr. JAMES said that it certainly did not seem to be the normal pattern. Had he understood Mr. Hunnisett to say that it was the head?

Mr. HUNNISETT said that it was perfectly flat, and there were no corners. It had been contacted by the flat surface of the punch. The part at which he had been looking had been extruded to four times its original area.

Mr. JAMES said that he would certainly not expect this result. It would seem to indicate imperfect phosphate coating to begin with, in that the coating had not even had satisfactory flow over that small area. What amazed him was that if the quality of the phosphate coating in that particular case was so bad there had not been severe pick-up where he had actually carried out the phosphate working, on the other part of the component.

Mr. HUNNISETT said that, to the naked eye, it

(*Continued in page* 207)

*Mr. Morgan's paper was published in the February, 1961, issue of *Sheet Metal Industries*.

Tool Materials for the

COLD-EXTRUSION PROCESS

(A paper presented at the special conference on the "Cold Extrusion of Steel" Sheffield, November 1960, organized by the Institute of Sheet Metal Engineering.)

By A. W. F. COMLEY, A.I.M., M.I.E.I., A.I.Prod.E.*

THE process of cold extrusion, probably more than any other of the wrought processes, is dependent upon maximum tool life for an economic output.

Quantities of components produced from any given set of tools must be high. The nature of the process is such that loading of tools is of a very severe nature. A consideration of these facts leads to the following assumptions: first, that the best type of material must be utilized in the manufacture of the tools; and, second, that the manufacturing process given to the tool must be of the highest class, and any thermal treatment applied to the tool must be equally beyond reproach.

A brief consideration of the operation of the punch in the cold-extrusion process when considered in conjunction with some of the reported loadings on the tool, indicate that the material is subject to a very severe fatigue cycle, a cycle where the stress reversals are low in number but where the stress range is extremely high.

Later on in this paper some of the published data with regard to loading on tools will be discussed in order to allow an appreciation of what the tool designer is faced with when considering the manufacture of tools for this process. In addition to this the author will discuss the various types of tool steels available, comment on the advantage or disadvantage of different grades and discuss thermal treatment that should be given to tools when manufactured from treatable steels.

In order to make a coherent survey the author will consider the problem from the point of view of a tool designer faced with the necessity of designing a tool set-up, for cold extrusion of a given component.

Selection of Tool Materials

The first problem is where to obtain the tool steel. There are in this country many suppliers of tool steels both of English, European and North American origin and in general the selection of tool steel is made more on a basis of familiarity than on a basis of considered approach. The majority of tool makers and tool designers have a steel supplier with whom over the years they have built up good relations, and to whom they turn for their normal supplies. It is quite possible that any given steel supplier will sell a good-quality tool steel suitable for most purposes; however, in the case of cold extrusion the author is of the opinion that the high demands placed upon the steel are of such a critical nature that second thoughts are necessary with regard to the steel supplier. It is specifically recommended that the steel used is purchased from manufacturers who control the whole process of manufacture of the steel from the casting of the ingot to the annealing of the final product. While it would be inopportune to mention any specific names, there are certain steel suppliers who should be in a better position to meet the demands of cold extrusion tooling than others.

When considering the choice of tool steel grade a wider discussion is necessary with the supplier than would be in the case of normal press-tool manufacture.

Presuming that a steel supplier has been selected whose manufacture is complete and beyond reproach, the designer must then specify the grade of steel. It appears from a survey made by the author that almost every grade of tool steel has been tried in the cold extrusion process with varying degrees of success.

Technical Data Survey

The following comments from various technical publications will give some indication of this variation.

Extract from 'Machinery' (U.S.A.) April 1954, *"Die Steels for Cold Extrusion—*

The materials used in the manufacture of cold-extrusion tools have been the subject of considerable development. A recommended material for dies is a water-hardening tool steel containing 1.1 per

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cent carbon, 0.3 per cent chromium, 0.35 per cent manganese and 0.1 per cent vanadium. An oil-hardening steel suitable for use in punches contains 0.55 per cent carbon, 1.5 per cent chromium, 4.5 per cent nickel, 0.9 per cent tungsten, 0.3 per cent silicon and 0.4 per cent manganese. The dies should be hardened from 58 to 60 Rockwell C. Although greater hardness may be desirable from the point of view of wear resistance, the fluctuating stresses to which the steels are subjected lead to fatigue. Therefore, adequate toughness must be assured. The presence of tungsten in the punch material is beneficial in preventing softening of the member which reaches a temperature ranging from 200° C. to 300° C. during extrusion operations.

Forged tool steels should be used. Large dies and punches requiring a pronounced change of section should be pre-forged. During the hardening of the dies, it has been found advantageous to direct a high pressure jet of water against the extrusion shoulder.

Particular attention should be paid to the surface finish of the tools, since an extruded part will have the same smoothness as the die in which it was produced. A surface finish of 10·0 micro-inches r.m.s. or less, can consistently be obtained. Lapping has proved to be very successful, although grinding or polishing operations may be performed. Whichever method is used, it should follow the direction of material flow.

All steels used for cold-extrusion tools should be of the highest quality and their heat treatment accurately controlled. Martempering can frequently be employed to advantage. Surface treatments such as nitriding and chromium plating have been used with a marked improvement in wear resistance.

Generally, die steels suitable for cold working operations should be resilient rather than tough".

Extract from "Tool Engineer" September 1954 *by R. H. Eshelman, "Tooling for Cold Extrusion—*

Since extrusion is the most severe of all presswork and loadings are extreme, tool design and materials are critical factors.

Because of high loadings the tools should be drawn or stress-relieved at fairly frequent intervals to offset surface fatigue. Carbides are being tried for various portions of the tooling to overcome these problems. Punches of carbide have been tested experimentally and have been reported in production on special jobs. Another recommended use for carbides is for inserts. The inserts may be die walls in backward extrusion or bearing areas and guides in forward extrusion or other points of great abrasion and pressure.

While the problem of finding satisfactory tool materials is complex, specific applications have been successfully developed. For example, the first materials used for the tools were unsatisfactory, giving a production of only about 3,000 pieces. A high speed steel 18.4.1 was found satisfactory for the punch producing over 14,000 pieces to date. A tool life above 30,000 pieces is considered good.

This punch was hardened in a salt bath from a temperature of 2,350° F. and double drawn at 1,050° F. to a hardness of Rockwell C 62 to 64 and given a liquid nitride treatment. A surface hardness of 72 to 74 Rockwell C was developed to a depth of about 0.001 inch. A special heating jacket has been prepared to hold the punch at operating temperature when the press is idle. The knock-out is also made of high-speed steel of the same hardness.

A manganese-chromium-molybdenum non-deforming, air-hardening die steel has been found to give good life in the ring die. So far, 23,000 pieces have been produced on the ring and it is still in operation. The hardness of the ring die is Rockwell C 58 to 60 secured with the standard heat treatment. One of the qualities sought in this steel was its uniformity of hardness from surface to centre, as failure of the ring was found to occur when strain exceeded elastic limit of the steel. In this application the ring die is a press fit into a four-foot diameter hardened retaining ring of Rockwell hardness C 34 to 36. Force exerted in the operation stretches the die so that the ID increases beyond the tolerance requirements, which must be held to 0.010 in. if specified wall thickness. Cold working of the slug in this operation increases hardness of the formed part of Rockwell B.90 from Rockwell B.60 in the slug".

Extract from "Machinery" (U.S.A.) July, 1955, *"Tooling for Cold Steel Extrusion by J. F. Leland, Parker Rust Proof Co. Punch and Die Life—*

Dies and punches, have, for the most part been made from various high speed steels, having a hardness ranging from 60 to 65 Rockwell C. Tool steel punches if properly heat treated can be expected to produce between 25,000 and 75,000 parts before fatigue failure occurs. With adequate lubrication wear is seldom a factor.

More recently, carbide tooling has been employed on production jobs. Well-designed set-ups have been used to turn out hundreds of thousands of parts with no sign of tool failure. It would appear that, with good control of various factors, there is no limit as to what can be expected in the way of tool life.

In the preparation of extrusion dies and punches, certain precautions must be taken. Care should be exercised to eliminate all grinding marks, even before heat treating, because it is at these grinding marks that stress cracks and fractures have their beginning. Wherever possible, final polishing on both the punch and the die should be done in the direction of metal flow.

Because tool design and lubrication have such a direct bearing on tool life, it will be found unwise to compromise on either factors. When trying to

obtain maximum reduction or maximum penetration, it is best to utilize the basic tool shapes, and then in a separate operation restrike to obtain the desired cavity shapes. In the case of lighter reductions and shallower penetrations, compromise can be made if the basic reasoning behind good tooling is borne in mind.

One phenomenon relating to poor lubrication, poor tooling, or both, is known as cross-checking. This usually shows up on heavily cold-worked areas. These fine hairline cracks on the work surface may not be accompanied by galling, but indicate a high rate of internal metal flow due to surface friction. Cross-checking results in a weak part having poor physical properties".

Extract from "Journal of Scientific Research", December, 1956, by Mahito Kunogi "A New Method of Cold Extrusion—

In this paper a new method of cold extrusion is discussed and the following are the comments made with regard to tool steels.

High-carbon chrome, tungsten steel, high-speed steel, high-carbon, high-chromium steel and cemented carbides have all been tested.

The following are the analysis of the tool steels used:—

(*a*) 1 per cent carbon, 0.8 per cent chrome, 1 per cent nickel.

(*b*) 0.8 per cent carbon, 4 per cent chrome, 18 per cent tungsten, 1 per cent vanadium.

(*c*) 2 per cent carbon, 14 per cent chrome, 3 per cent tungsten.

The results obtained show that a high-carbon chrome tungsten steel (*c*) gives the best results when used as a punch. Reference is made to the punch being used under pressures of 300 kg. per sq. mm. Tests on punch material SKD 2 which is a carbon-chrome composition again gives best results at a compressive stress of 280 kg. per sq. mm., and the results of this test indicated that the stable limit is 250 kg. per sq. mm.

Tests on punches made from cemented carbides show that they can withstand stresses greater than 300 kg. per sq. mm. but brittleness gave erratic punch life".

Extract from "Metalworking Production", January, 1958.

The finish of the profile or nose end of the punch is important. Any rough surfaces or sharp edges will cut through the lubricant on the slug and cause galling and an increase in pressure. Finish of the transition section is likewise important. Any grinding marks here will cause stress raisers and ultimate failure of the punch. Most punches require a finish of 4 micro-inches or less. The punch should be lapped in the direction of metal flow.

Selection of the proper grade of tool steel, carbide or other tooling material is based upon the direct loading in pounds per square inch and the elastic limit. The hardness range for tool-steel parts is usually from 65 to 67 Rockwell C. Even so the tools will yield under compression loading and cause variable base thickness when there is a difference in alloy or hardness of the material being extruded. Combined yield of punch and pressure anvil may be as much as 0.062 in. (an experimental set up) and yet tool life has been excellent, over 150,000 pieces per punch. Tool life of a pressure anvil is approximately 20 times that of a punch.

The diepot consists of two members; the die insert and the backer or shrink ring which confines pressures within the die pot. This combination of units is a pressure vessel, which must resist horizontal or bursting stresses. The shrink ring is designed to resist these stresses.

1. Finish requirements on the inside of the diepot are the same as for the punch.

2. The die insert is usually of a high-grade alloy tool steel (65 to 67 Rockwell C) or of carbide. Usually the exterior of the die insert is round for ease of fitting within the shrink ring. The shrink ring must put the die insert in compression in its normal or unloaded state. Then when the diepot is subjected to the internal pressures of extrusion, they will be neutralized by the external pressures of the shrink ring and the die insert will remain in compression. Should there be any excessive yield, a "choke" characteristic is introduced which increases extruding pressure requirements. The pressure area within the die insert is usually near the centre of the unit. Any increase in diameter at the centre by yielding will result in a smaller diameter at each end. When this takes place, the extruding material moves upwards into a smaller diameter, thus creating a choking action. The results are high pressures and ultimate breakage of the diepot due to fatigue failure. For these reasons the load on the punch in pounds per square inch is used as the bursting stress for the die insert. To obtain the compressive stresses required in the die insert, a rule-of-thumb method is to use a shrink fit of 0.004 in. per in.

3. The material usually used for the shrink ring is a hot work alloy tool steel at 50 to 52 Rockwell C. The die insert and shrink ring are under lifting pressures, rather than downward pressures. The force attempting to pull the die up out of the insert must be compensated for in securing the shrink ring to the die.

Extract from Nel Plasticity Report No. 163.—The Extrusion of Metal Part VIII—Steel under Cold Impact Conditions, September, 1959, by J. McKenzie and A. R. Rodger—"Performance of Extrusion Tooling":

"1. *Die Wear*—The assessment of die wear was not possible, since the number of extrusions was limited and each tool was subjected to a variety of conditions and high compressive stresses. Die wear was undetectable with good lubrication and

any tool metal contact, due to poor lubrication, immediately resulted in galling.

2. *Die Failure*—Failures were experienced with the crushing of the sharp edged dies under compressive stresses in excess of 200 tons per sq. in. This caused cracks in the plane of the die shoulder below the surface, combined with short longitudinal cracks radiating outwards. When the product was subsequently ejected from the die, the movement in the reverse direction caused small segments of the die to become detached from the contact face. Certain die faces deformed prior to cracking, producing a slight reduction in the diameter of the die. This type of failure did not occur with a die having a slight conical profile (150 deg. and 120 deg.) and a cone angle entry combined with a small radiused edge might prove a most effective profile.

Dies were normally made from a 1 per cent C., 0.85 per cent Mn, 0.75 per cent Cr, 0.4 per cent W steel. Sieber and De Griat report the use of extrusion tools in tungsten carbide with cobalt contents varying up to 30 per cent under production conditions while Kunogi used tungsten carbide tools which were subjected to punch pressures up to 200 tons per sq. in. under research conditions.

3. *Pilot Failures.* All pilots were made integral with the punch body and provided with a liberal radius at the root; a small radius resulted in failure of the pilot at the root, a typical case being that of a pilot used in the extrusion of the 0.017-in. thick tube wall. These pilots were all provided with a 0.0005 in. per in. relief taper on the diameter.

4. *Punch Failures.* Certain punches used for the extrusion of rod and made from a 2 per cent C, 12 per cent Cr, 0.8 per cent Mo, 0.25 per cent V tool steel failed when they barrelled due to inadequate heat treatment. Excessive pressures, however, caused hair line cracks to develop on the face of the punches, which has been heat-treated satisfactorily. In the latter part of the investigation a punch in an 18/4/1 high-speed steel gave good service.

In the extrusion of cans, failures occurred due to instability, since the punch was not laterally restrained.

The maximum values of direct compressive stress to which certain punches were subjected during the extrusion of cans were plotted against the length to diameter ratio of the specific punch and failures The punch was treated as a column with its top end fixed in position and direction, and with its bottom end free which, from a study of the punch failures, seemed reasonable. The limiting condition was derived from the buckling formulas of Euler and Johnson. The latter was a modification of the former to account for the compressive yield stress of the column material at low slenderness ratios. The crushing stress of the tool steel was assumed to be 200 tons per sq. in. which was conservative,

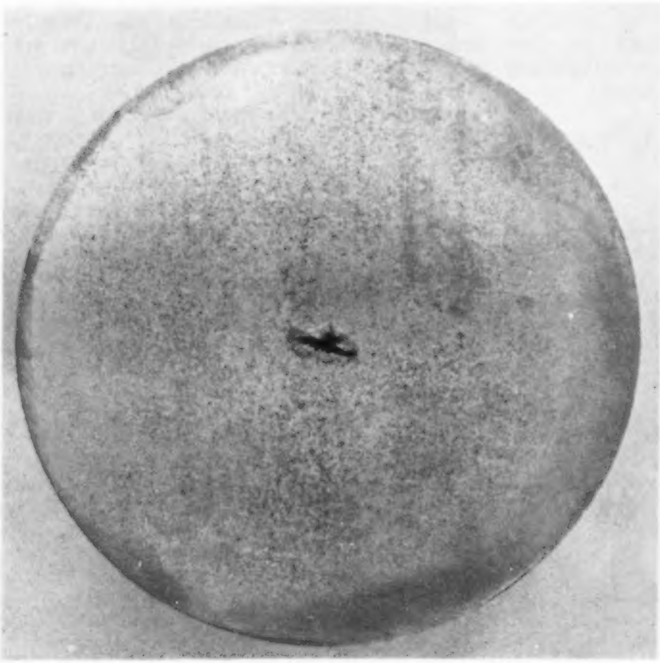


Fig. 1

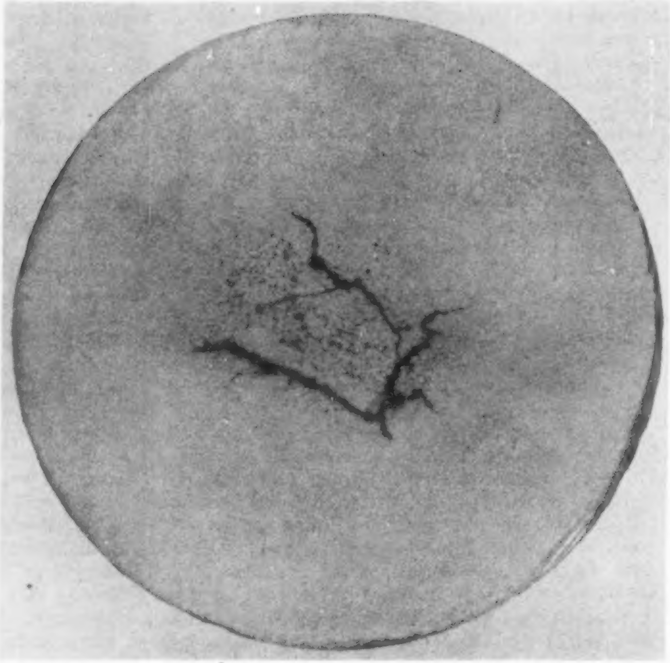


Fig. 2

since punches and dies had been subjected to higher values of compressive stress without failure.

In establishing the limiting line the punch was assumed to be initially concentric with the extrusion chamber, but products with an initial eccentricity up to 0.010 in. were successfully extruded without failure.

A punch provided with a nose profile, having a larger radiused chamber tended to wander during the extrusion.

5. *Chamber Failures.* Extrusion chambers normally failed due to heavy longitudinal scoring of the bore as a result of metal pick up between chamber and fitting punches, or to flaking at the bottom edge of the chamber in contact with the die face. The failures due to flaking were similar to those experienced by other workers where the integral chamber and die cracked at the junction of the die and chamber.

The development of tougher and harder tool steels and the use of tungsten carbides is required to improve extrusion tool life, and make the cold extrusion of mild steels above an extrusion ratio of 5 and of harder steels economically possible on a production scale".

Proceedings of the Iron Steel Institute Volume 195, *Part* 3, 1959.

R. A. P. Morgan of the Royal Ordnance Factory, Birtley commented that high silicon steels produced 50 per cent more components than high-carbon, high-chrome steels previously used; because high-carbon high-chrome steels were unreliable, high-speed steels were being tried again. He also remarked that in trials, punches made from high-chrome, high-carbon steels were very unreliable some having fractured after making only 200 components, but the same punch on the next material made to 7,000 pieces. His comments on dies were that no trouble had been experienced, 40,000 to 50,000 pieces being pressed.

In work in which the present author was previously involved, concerning the cold extrusion of shells high-carbon, high-chrome steel was used for the punch and water-hardening steel for the die, the steel being 0.1 per cent C., 1.0 per cent V. In this field of experience there was agreement with the comments of Mr. Morgan, no trouble being experienced with die life, but there was a very erratic punch life.

A point that should be made clear at this stage is that many steels have been tried and the results obtained, when comparing comments from different sources, are often at variance. It is therefore apparent that local conditions severely influence the performance of cold-extrusion tools.

At this stage the tool designer needs to consider what he is going to buy and what he needs to know about the steel he is to buy. He is going to buy a piece of steel which in its manufactured history has been subjected to continual high temperatures

Fig. 3

and continual attack by oxidizing atmospheres. In addition other troubles exist; one of the commonest of these found in highly-alloyed steels is segration which occurs in the bar, this can take two major forms:

(1) Segregation in the centre of the bar, which may be indicated by an actual defect, a residual pipe or the high occurrence of certain impurities.

(2) The occurrence of an agglomeration of carbides.

Both of these defects can give trouble under conditions of high loading. Figs. 1 and 2 show a typical indication of the first defect *i.e.* piping in the centre of a piece of tool steel as revealed by the hot acid etch on the piece of steel. Fig. 3 indicates a second type of defect which is ingotism segregation; both these defects are controllable to a certain extent by the steel manufacturer and are associated with the amount of manipulative work applied to the steel in its transition from the ingot to the finished bar. The author does not propose to tread on such dangerous ground as to try to tell the steel maker what he must do to avoid that, especially in Sheffield; in general however, it can be said that the larger the bar diameter, the more possible it is for the second condition to exist and the smaller the bar the more working it receives, which breaks up this type of condition. It well behoves the tool designer designing an expensive tool to have the bar checked first of all for these two defects. The average cost of a bar of high-carbon chrome steel 10 ft. long, with a 3 in. diameter is £45 to £50 and the cost of manufacturing the tool is extremely high. It is appreciated that the facilities are not always available at a given firm to carry out microscopical examination and hot etching. Under these circumstances it is suggested that the customer asks the supplier to sample a bar and allow him or his representative to inspect the result. With a firm having laboratory facilities this problem is fairly simple and it enables a selective choice of tool steel to be made. From experience, a sample from each end of a 10-ft. bar is fairly representative of the whole of the bar.

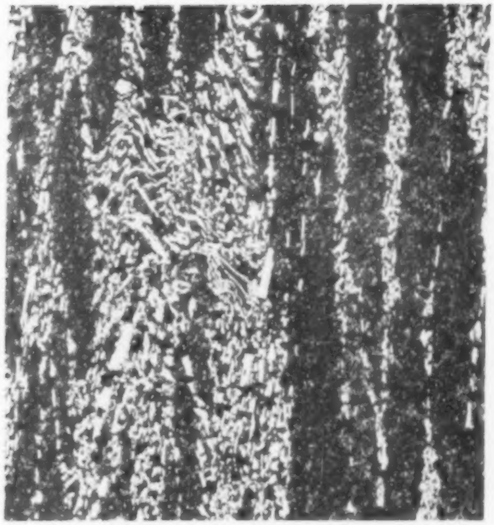
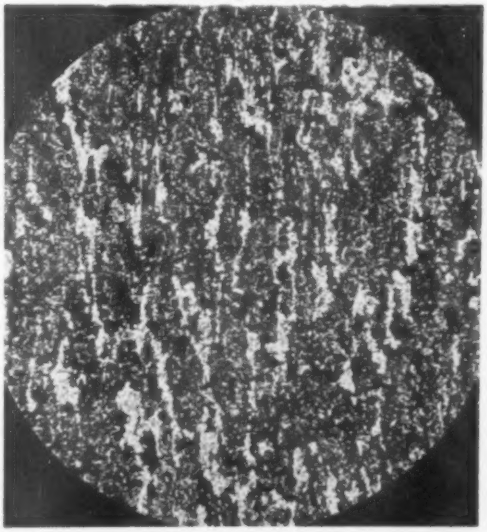


Fig. 4 (× 300)

Fig. 5 (× 100).—½-in. from periphery



medial position

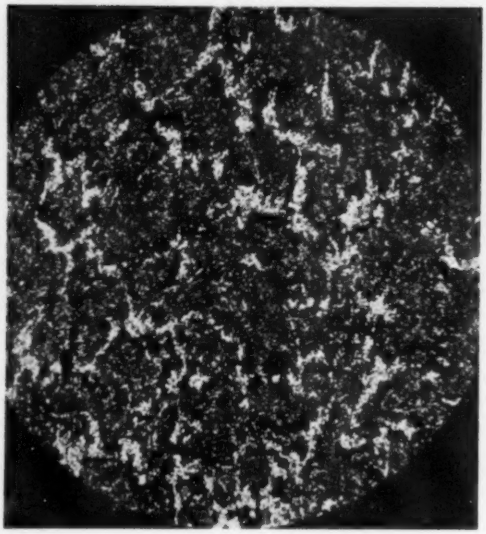


Fig. 6 (× 100)

axis

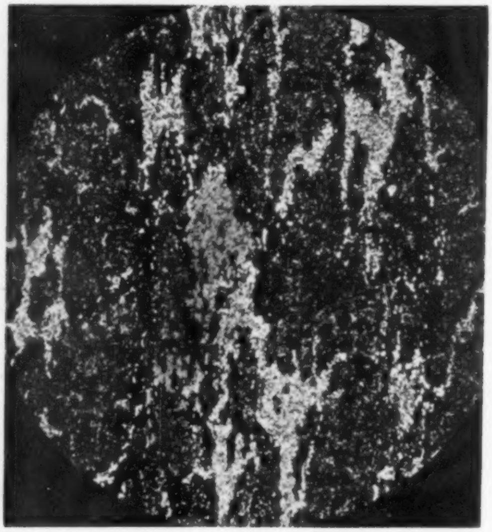


Fig. 7 (× 100)

A most important feature which can occur in highly alloyed tool steels is carbide segregation (Fig. 4). It will be seen from this that the segregate exists in marked striations, which run in the direction of rolling.

Figs. 5, 6 and 7 show how the carbide segregation can vary over a large diameter bar (5 in.) 18/4/1 quality. Fig. 5 shows typical structure ½ in. from the surface. Fig. 6 shows typical structure halfway between the axis and the outside of the bar and Fig. 7 shows the centre axis of the bar.

Another aspect of carbide is the occurrence of massive carbides. Fig. 8 illustrates how such carbide out-cropping at the surface of a tool can give rise to pitting, due to the flaking away of massive carbide particles.

These defects can be met in almost any grade of tool steel and it is important to establish, before manufacturing commences, the occurrence and severity of such conditions. It is essential to realize that very little can be done in any thermal treatment to break up segregations of this nature, especially with the high carbon, high-chrome steels.

Material produced by hot forming always has a more or less coarse surface by reason of the nature of this process, and surface defects can be present which originate from the ingot, or appear during the heating and rolling. It is true that the steel is carefully inspected after rolling, but a certain roughness of the surface must always be allowed, and in point of fact minor defects cannot always be seen. Steel which is delivered unannealed and unpickled is always covered with an oxide layer which can disguise surface defects. Annealed tool steel is usually pickled in acid before annealing which removes the oxide layer but even then it is difficult, or almost impossible to detect scratches, pits and smaller cracks in the pickled surface, and even if these could be detected, it would be impracticable to remove them on account of the high costs which would be involved.

Fig. 8 (× 300)

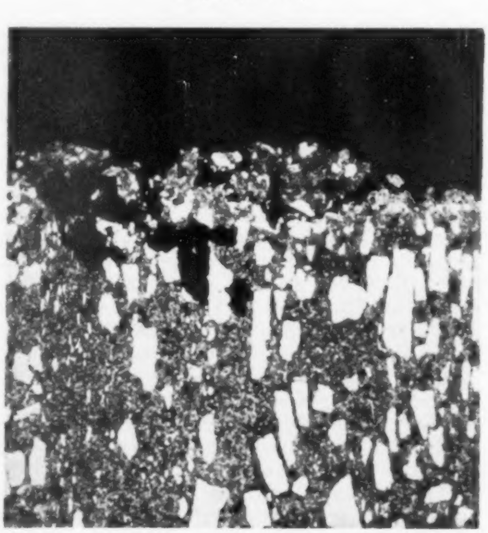


Fig. 9

Fig. 9 shows a hot etched tool-steel bar containing surface defects of this nature.

Steels with a high carbon content always suffer from a certain amount of surface decarburization, during the repeated heatings for forging and rolling. This decarburization is further increased during annealing and the decarburized surface cannot be fully hardened, and soft spots would appear if it is not removed.

From hot-rolled annealed steel a typical degree of decarburization is:

$$0.01D + 0.025 \text{ in.}$$

where D = bar diameter or thickness.

It should be observed that by decarburization is meant a certain surface layer, and this is always measured on the radius or on half the thickness. Decarburization is usually greater with forged steel. The formula given above is intended for microscopical methods of examination. There are other methods of determining decarburization which usually give somewhat different results. Fig. 10 illustrates a typical decarburized layer.

The metal can be ordered as machined bar with a guarantee from the supplier that the machining has been sufficient to remove all traces of defective surface: on the other hand the raw bar which is bought in unmachined needs to be given the maximum amount of machining by the tool maker.

For the reasons given the surface must always be removed to a certain depth when machining tools. This is especially important for parts which are to be hardened. The smaller defects increase in depth during hardening and will possibly result in failure.

Alloy steel often has a greater tendency to surface defects than carbon steel.

Machining Allowance necessary for Tool Steel

By the term machining allowance is meant the thickness of the surface layer which must be removed from the rolled or forged steel in order to obtain the finished size of the tool being produced. The machining allowance is the addition to one side, and the size of the blank should be increased by twice the machining allowance. The finished article is required to be free from surface defects and decarburization.

In calculating the machining allowance, therefore, the following factors must be taken into account:

1. Rolling or forging tolerance;
2. Surface decarburization;
3. Normal surface defects;
4. Degree of straightness;
5. Eccentric alignment in the lathe etc.

Recommendations regarding machining allowance must always be approximate but it is better to allow too much than too little and it is suggested that, for cold-extrusion tools, at least $\frac{1}{4}$ in. be removed from either side of a 3-in. diameter bar.

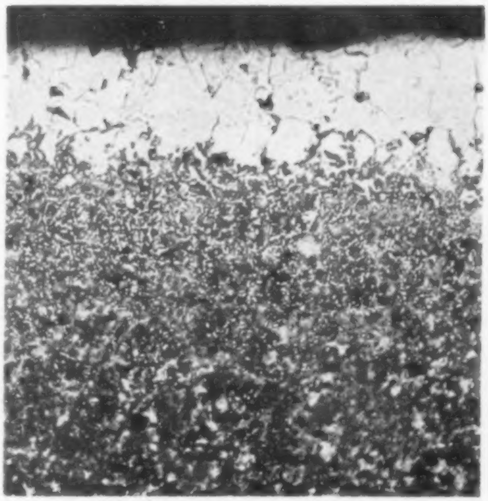
For rolled and annealed bars of tool steel the minimum machining allowance can generally be calculated to the formula:

$$a = 0.025D + 0.025 \text{ in.}$$

where D = the diameter or thickness of the steel. The above formula applies to round and square sizes as well as those flat sizes, where the width is only slightly greater than the thickness.

For rolled flat sizes, where the width is large compared to the thickness, the working allowance on the thickness differs and mainly depends on the width. This circumstance may seem somewhat

Fig. 10 (× 200)



strange and can partly be explained by the fact that with flat sizes a certain amount of warping must be allowed for, which becomes more pronounced the wider the material.

For forged rounds and squares a somewhat larger machining allowance should be calculated than for rolled bars. The formula for forged bars, therefore is:

$$a = 0.03D + 0.050 \text{ in.}$$

The next thing which should be done is to crack-detect the tools at the rough machining stage. This can be done by magnetic means; there are on the market, for the benefit of firms who do not possess such equipment, extremely efficient dye penetrants which are available nowadays in aerosol containers and this type of treatment will positively show whether there are any remnants of cracks which may influence the life of the tool. It is most important to carry out this test at the rough machined stage prior to any heat treatment. The presence of a small defect can mean the loss of a tool by acting as a source for a hardening crack in any thermal treatment which is subsequently done.

The general conditions for obtaining stress-relief of tool steels are well known, the necessity for such treatment being well emphasized in manufacturers' catalogues. Nevertheless it is a point which can be missed and stress relieving after rough machining is essential.

The next important thing in the stage of material utilization is the thermal treatment itself. Far too often firms who have spent a great deal of money in designing and manufacturing tools completely neglect to provide the same care and thought for the heat treatment of these tools. It is always a problem to decide the best type of heat-treatment

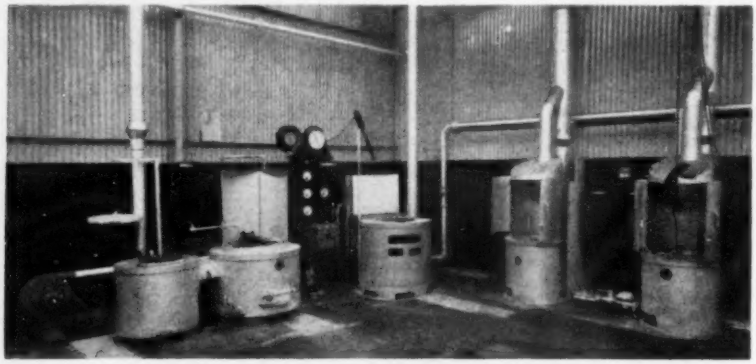


Fig. 11

Fig. 12

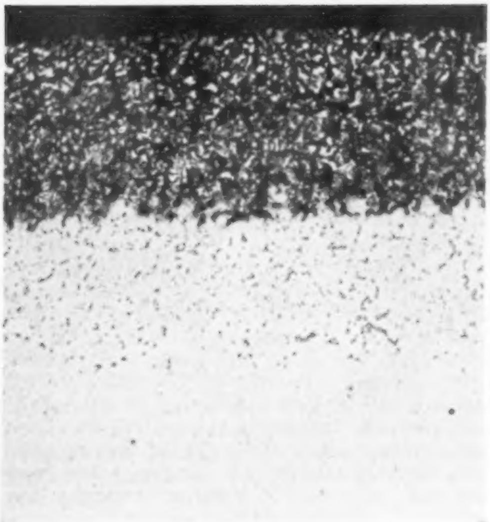


Fig. 13

plant but a salt bath is suggested as the basis of any tool treatment plant. The advantages of this process appear to outweigh any of its disadvantages when compared with other types of plant. Figs. 11 and 12 give a good example of a well-laid-out tool heat-treatment plant based on the salt-bath method.

Any plant laid down for tool heat treatment should have the following minimum requirements:

1. Adequate pre-heating;
2. A salt hardening bath capable of dealing with high-speed steels;
3. Tempering and stress-relieving equipment.

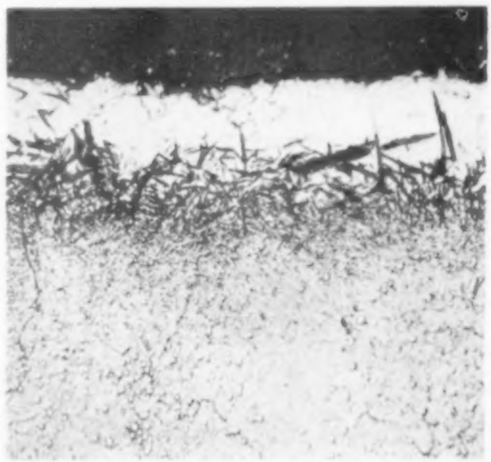
It is quite possible to utilize low-temperature salt baths for a number of differing processes such as tempering, stress relieving or interrupted quenching. Anyone considering the installation of a tool hardening plant who has not the facilities for laboratory control should make it their business to see that those responsible for hardening have at least an elementary knowledge of such principles; this information is freely available from most tool steel firms. The author emphasizes this point, because having dealt with tool hardening staff frequently, both in the employment of large firms and contract tool makers, he has found that often the hardener has no real knowledge of the elementary principles of metallurgy and frequently no one has ever made any attempt to see that such knowledge is available. A major fault is a lack of appreciation of the correct temperatures at which stress relieving must be carried out, and here again it is of great value if the operator appreciates that stress-relieving temperatures in excess of those stated would have a detrimental effect on the final hardening of the tool as well as affecting any further manipulation in the manufacture of such a tool.

With regard to the heat treatment itself, it is better to follow the manufacturer's data implicitly, because tools can be scrapped in heat treatment, very often through a combination of causes which are difficult to establish. If therefore, the heat treatment operator is given strict instructions to follow a recommended heat treatment, one variable is removed.

A point of error which is not always appreciated is the fact that excess soaking time at temperature, with some of the more highly alloyed steels can be as dangerous as under heating with regard to a final satisfactory product. Carburizing salt baths are used for the heat treatment of tools, and indeed many tool steels benefit from the slight carburizing condition in the bath; however Fig. 13 illustrates a condition where such a treatment is unsatisfactory. The micrograph shows a surface condition on a tool manufactured from a 1 per cent carbon, 5 per cent chrome steel and what has happened is that the long soaking time normally recommended for high-carbon, chrome steels has resulted in a complete structural change on the surface of a layer of about 0.002 in. depth which has been formed consisting of oxides and carbides, such a layer being fairly soft and flaky.

Fig. 14 shows a defect which can occur in box furnace heat treatment due to utilizing cast-iron shavings as a protection medium; while this is normally quite satisfactory, in this case the cast-iron shavings had an oil film over them sufficient to produce a slight carburizing atmosphere in the box with the result, that, on this particular tool a soft

Fig. 14



skin was formed due to retained austenite. A neutral salt bath should therefore be used as a basis of the hardening process as neither decarburization or carburization will occur if the plant is maintained correctly.

Plant for tool hardening should have satisfactory cooling media and water, air, salt and oil are the four basic methods. All liquid methods must have adequate circulation to ensure rapid and equal cooling. The water quenching baths require the most vigorous agitation as formation of steam bubbles can have a distinctly degrading effect on hardenability. Fig. 15 shows two tools, water quenched, which had received insufficient agitation, the hardened areas on the surface are quite obvious, as indeed is the lack of uniformity. Requenching of these tools produced a satisfactory result. Salt quenching is an extremely satisfactory way of dealing with highly alloyed steels and complex shaped tools as it enables abrupt changes of section to be dealt with without too great a risk. Where abrupt changes of section are unavoidable it is as well to use an air-hardening steel.

Oil quenching requires the same considerations as for water, adequate circulation of the oil is an essential requisite.

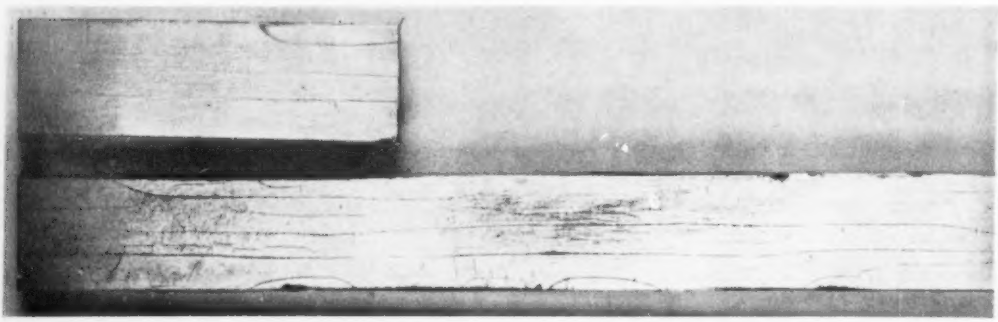
Air quenching may be done either with a fan or in still air. If fans are used then they should be multi-directional and not one fan blowing from one side as this would cause distortion during the cooling down in the transition stage from soft to hard.

With regard to the tempering operation and with the type of materials used for cold extrusion tools, double tempering is essential. When highly-alloyed tool steels are heated they change in structure, rapid cooling down to room temperature causes a change in structure to the hardened condition. However it frequently happens that with such steels a small percentage, probably about 5 per cent does not change to the hardened condition on quenching; this change actually takes place after the first tempering operation, so that in effect you have a small but significant percent in a fully hardened and untempered condition. As this second change only occurs on the tool reaching room temperature, it is of no valid use merely to increase the tempering time. The second tempering then tempers the hardened 5 per cent and rectifies a possible weakness. After these tempering operations, there still may be a minute amount of material in a state where it can change to the hardened condition, and it is a point the author will consider at a later stage.

Fig. 15

The stage has now been reached in the survey of the manufacture of the tool, where a heat treated component has been produced. After heat treatment comes the final operation of the tool, this being grinding and polishing. The heat generated in grinding can be so great that stress relief of the hardened tool cracks the surface and it is insufficient to rely on visual examination for grinding cracks. All tools after grinding should be crack-detected either with a magnetic crack detector or by the use of die penetrants. Fig. 16 shows some typical grinding cracks of a more familiar type. In order to distribute the stresses set up in grinding it is again essential to stress-relieve the tool, prior to finally polishing. This treatment should naturally

Fig. 16



be done at a temperature just below the final tempering temperature of the tool and would be considered then as a third tempering operation.

The finishing of the tool is normally done with diamond cutting-agents as grinding with the normal type of wheels must induce on the tool surface sharply angled markings. There is no doubt that such markings, whether radial or longitudinal can act as stress raisers under the extremely high load concentrations which exist. The very fine particle size, 0/3 microns, of diamond abrasives reduce this risk to a minimum and consequently should be utilized.

Referring back to the point made of the possibility of the existence in the finished tool of a small percentage of material still ready to change to the hardened state, it is possible that this change can occur, due to stress set up in the first few operations with the finished tool, and therefore after a number of operations, say 50, the tools should be taken out and tempered and the production cycle recommenced.

Selection of Tool Steels

Examination at various times of faulty punches has given strong evidence that a possible prime cause is a defect which would be referred to as heat checking in another industry. The thermal cycling which occurs on the surface of the cold extrusion tool must be very wide and the most successful punch steels probably come from the group of materials used in hot work industry. These can generally be summed up in the following groups:

- 5 per cent chromium steels
- 9 per cent tungsten steels
- 18/4/1 steels
- the new 12 per cent cobalt, 9 per cent tungsten steels
- nickel-chrome steels, B.S. 224.

A letter received from an American steel firm mentioned that they were having very great success with the use of a 0·35 per cent carbon, 5 per cent chromium steel with 1½ per cent molybdenum. This type of steel is to a certain extent replacing the 9 per cent tungsten steel in a number of applications. This steel was utilized in a case-hardened condition and it is obvious that some conditions exist in steel of this type which are useful. The carbon content is sufficiently low to ensure a very tough core. After full quenching the molybdenum, silicon and chrome give desirable hot work properties and the increase in surface carbon can, after case hardening add wear resistance. It would be expected that this type of material would stand up very well indeed to the extrusion process. The molybdenum high-speed steel has very high compressive strength and in addition contains good resistance to heat checking and the best results should be obtained from those high-speed steels with a somewhat lower than normal carbon content in order to increase shock resistance.

With regard to the selection of die steels there is less difficulty, the carbon chromium steels of the 2 per cent C.; 2 per cent Cr. appear to give a generally satisfactory performance. As mentioned earlier on in this paper, with the cold extrusion of shells, water-quenched carbon steels gave satisfactory results provided that they were bore quenched with a heavy flush of water. Restraining the cooling so that it occurs only in the bore enables very high shrink stresses to be set up on the hardened bore which are very favourable in a forward extrusion die. The problems with dies are not considered to be quite as serious as with punches.

A point on which, so far as can be ascertained, very little work has been done, is the use of forged tool blanks for the extrusion process. This must be a worthwhile field of investigation, especially with the higher alloyed steels, where by judicious forging, the planes of possible weakness formed by carbide segregation, could be placed into a more favourable direction, as, almost inevitably they run longitudinally down the tool, when it is machined from rolled or forged bar.

The question of surface treatment of steels used for extrusion tools is one which merits some consideration and here the author offers his own view which is simply "not to put anything on to a surface, if you can put it into a surface"; by this is meant that surface treatments such as hard chromium plating offer a much larger margin for error than surface treatments such as carburizing or nitriding.

A treatment which may be of some benefit in the cold extrusion process is the Sulfinuz process where sulphur is introduced into the surface in a similar way to carbon in the carbonizing process, which gives under certain conditions a positive improvement from scuffing. The difficulty with this process when applied to extrusion tools is that it is done at around 500° C., and consequently can only be used on steels of the high speed type, when maximum hardness is required.

The work with which the author was personally involved mainly consisted of the use of highly polished punches. Some experimental work was done with a phosphated-coated punch and a molybdenum-disulphide lubricated punch; but no significant benefit could be traced to these treatments.

I have deliberately omitted to discuss what might be done with regard to new types of steel, vacuum melted steels etc., because the people concerned with cold extrusion at present have to utilize available materials; so many problems occur between the development and marketing of a major break through in tool-steel strength and purity that detailed discussion has no basis of validity in a paper of this type.

Tungsten Carbide

The use of hard metal in steel extrusion has

developed from the needs of the screw and bolt industry. Some aspects of "forward extrusion" and "cold flow" of ferrous materials, which in many quarters are considered to be developments of the last five to six years, have been commonplace in the bolt industry for probably 40 years. In cold heading, at the same time as upsetting of the head, that portion of the headed "Blank" which is ultimately to be thread rolled is reduced to a diameter approx. equivalent to the effective diameter of the thread concerned. A die for such a process would cost probably £35 to £40, and a production of probably 250,000 high tensile bolts could be obtained before wearing oversize on the sizing diameter. A similar cast-steel die, costing probably £6 to £7, would produce approx. 10,000.

Toughness is obtained in tungsten carbide by the addition of cobalt, the higher the percentage of cobalt, the greater the toughness and conversely the lower the hardness. The carbide would be a 25 per cent cobalt grade. This is extremely tough, with a very low hardness figure for hard metal, in the region of 950 VPN, a transverse rupture strength of 400,000 lb. per sq. in., and compressive strength of 525,000 lb. per sq. in.

For smaller diameter components a harder and less tough grade, with a greater wear resistance could be employed. Such a grade could be 16 per cent cobalt VHN 1200, transverse rupture 300,000 lb. per sq. in., compressive strength 575,000 lb. per sq. in. With a diameter of component approx. $\frac{1}{4}$ in., and a reduction of area approx. 23 per cent, 1,500,000 components head upset and shank reduced with a wear on sizing diameter of 0.001 in. Material extruded similar to EN 111 Steel.

While the normal reduction in shank diameter for such components is 20 to 25 per cent, much larger reduction in special fasteners have been achieved, up to approx. 70 per cent. Such dies have to be designed in such a way that the whole of the blank must be retained in the die during extrusion. This type of work is particularly applicable to "progressive" headers, such as the National "Boltmaker", and the development of this type of machine (outside the bolt industry also) with its high-speed production, has only been possible due to the successful application of carbide dies. It is by no means unusual for 10 million $\frac{1}{2}$ in. diameter components to be produced from a single first station extrusion die on this machine.

These "progressive headers" with four or five stations, are now being widely used outside the fastener industry, for special components, and a typical example of this is in the bearing industry, where needle bearing cups are being produced in this manner. Carbide dies, again in 25 per cent cobalt grade are producing an average of 2,000,000 components.

It is from this background of proved development that hard metal is now being applied to tooling on the more recent developments in impact extrusion of ferrous materials. In the case of intricate shapes, calling for projections in the die, carbide, at least in its present form of development, is still not a proposition. Such an example is a gear die. On the other hand, problems which were originally present in the production of shouldered components have now been overcome by removing stress points in the die at the change in section. This has been done by the use of inserts split through the horizontal axis of the form at the point of change in section.

As far as design principals are concerned, it is advisable to maintain a ratio of 2 or 3 to 1 between the bore and the diameter of carbide insert. Similarly the case or shrink ring should be at least double the diameter of the insert. Recommended case material is an alloy steel with a tensile associated with a hardness of 45 to 48 RC., and interference of 0.004 in. to 0.006 in. between insert and case is recommended, based on circumstances, and this may be affected by shrinking or cold pressing. In some instances on heavily loaded dies, double shrink rings are recommended.

As regards carbide punches, a typical example is the production of solid end cylinders, such as master cylinders in brake units. Here the extremely high compressive strength of hard metal is used to good effect, overcoming the bulging condition that arised under extreme conditions when using Tool steel. Under these conditions when high length to diameter ratios persist, the stripping load is fairly high, so that a carbide grade of intermediate cobalt content, in the range 12 to 14 per cent is called for. Such a grade has a transverse rupture strength of 280,000 lb. per sq. in., VPN 1300, and a compressive strength of 620,000 lb. per sq. in.

Underlying all aspects of the application of carbide tooling to extrusion the characteristics of the material are such that a small grinding mark in a punch, or an unduly sharp corner in a die, can produce undesirable notching effects to cause rapid fracture. Similarly, press slides should be in ideal condition, and any detail likely to give rise to punch deflection must be eliminated. It is only by observing all these conditions that the admirable properties of hard metal can be thoroughly exploited.

Conclusions

The author cannot conclude a paper of this type without making a specific recommendation therefore, if asked to select a combination of materials for punch and die he would state molybdenum high-speed steel for the punch and carbide for the die, if die design is unsuitable for carbide then a high-carbon vanadium water-hardening steel for the application.

The main points to consider are:

1. Buy material with a known history from a fully equipped supplier.

2. Carry out all manufacturing operations in accordance with the material supplier's recommendations.

3. See that the heat treatment of steels are carried out under completely controlled conditions.

4. Record most completely the history of every tool; the bar it was made from, the condition of the bar, the heat treatment it was given and its final hardness.

5. Carry out a system of crack detection throughout the manufacture of the tool.

6. Whenever a steel tool is taken from the tool set it should be stress relieved at a temperature just below its final tempering temperature as a matter of routine, and crack detected before re-use.

Acknowledgements

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Edgar Allen Ltd., Samuel Osborne Ltd., William Jessops Ltd., English Steel Corporation, Imperial Chemical Industries Ltd., Wickman Ltd., Carpenter Steel Company of America, Plessey Company, Ilford.

Thanks are also expressed to Mr. C. W. Robinson, managing director of Uddeholm (England) Ltd., for permission to utilize material obtained while in their employment.

DISCUSSION

Mr. D. SETTLE (Jessop Saville Ltd.) said that, as the representative of a steelmaker, he would like to refute one statement made earlier to the effect that vacuum-melted materials were not commercially available. He would be glad to take the particulars of anyone desiring it!

Mr. ROGERS (Hadfields Ltd.), referring to the more technical aspects of tool-steel selection, said he did not think that it could be divorced from some of the comments Mr. Morgan* had made in his paper. On the question of design, obviously, in the selection of any steel for any duty, it was necessary to take into consideration the operational conditions as far as these could be estimated.

Mr. Morgan had mentioned that no one had investigated the question of stresses in extrusion tool assembly. He would like to take him up on this point. The company with which Mr. Rogers was associated had done a lot of work in this connexion, and it was not of recent origin. The discovery that, for a highly loaded punch, it was preferable to use a tapered head, went back possibly 30 years so he would like to dispense with any thought that the British steelmakers and engineers were well behind the Continent in these problems.

In order to calculate the stresses, it was necessary to start with a datum line; it was necessary to know what radial pressures were likely to be encountered, and this could be easily overcome by fitting strain gauges to the outside of an assembly. At present, many of those engaged in cold-extrusion, spoke in terms of 60 tons per sq. in. and 70 tons per sq. in. Why they wanted this, he did not think, to be quite frank, they knew. They spoke in terms of excessive interference fits. Mr. Comley, for instance, had mentioned one of 0.004 in. per inch. He would submit that this was excessive and likely to do much more harm than good.

Availability of Vacuum-melted Steels

He would like to endorse the views of the previous speaker to the effect that vacuum-melted steels, by a number of processes, were readily available. The Sheffield steelmakers were not unaware of the problem. They looked to the cold-forging industry to supply them with certain basic data, for instance, on the die. Was the mechanism that they had to look at in the die abrasion or lack of strength? The two were diametrically opposed, and it was not possible to provide both at the same time.

Mr. COMLEY said as his paper dealt with "materials" he had been careful to avoid theoretical tool design. It was far too technical and mathematical, and when he had seen Mr. Morgan's paper he was very glad that he had not mentioned it. The difficulty was always that when considering loads on tools there was always the difficulty of the difference between theory and practice.

Mr. A. G. SHAW (Uddeholm Ltd.) asked Mr. Comley to enlarge on his preference for the salt-bath for heat treatment.

Mr. COMLEY said that it was a personal preference. If there were any furnace manufacturers present, he was sorry, but in the case of fairly small tools the salt bath did the job very satisfactorily. An advantage of salt was that it was a clean operation; it protected the steel. In the case of most cold-extrusion tools the finishing operation was undertaken after a heat treatment, and was followed by polishing. Salt baths could be explosive, but simple good housekeeping should prevent this. Also, they did decrease the possible distortion. The input of heat from a salt bath was faster than that from a furnace, especially when the work was boxed up. It was always preferable to get a tool hot quickly. It used to be said that tools could be cracked by getting them hot too quickly. He had never found this, if the steel was well annealed and properly stress-relieved, however, as most salt baths had a pre-heat arrangement at the side; after paying for the apparatus one might just as well use it properly. It was possible to over-emphasize slow-heating. What was important was that the time at temperature should be adequate.

*Mr. Morgan's paper was published in the February 1961 issue of *Sheet Metal Industries*.

(The author then showed some slides of graphs which illustrated the various degrees of distortion exhibited by various types of heat-treatment plant). He added that they were all quenched in oil. One had been heated in a hearth furnace, one in salt and another in salt at a low temperature followed by oil quenching. It showed a marked difference. He could not guarantee that the difference would be obtained every time, but it usually followed that the amount of distortion present on tools of the long, thin punch type was reduced by the use of salt rather than conventional box furnace hardening. A second slide shown illustrated the distortion in ball races when quenched by three different methods.

One thing that he would like to point out was that while he had shown a number of photographs in his paper, of very bad tool steel, he had not shown any of good steel.

Retained Austenite

Mr. G. C. Nutting (Wilmot Breeden Ltd.) said that the author had dealt with types of defects caused by condition of materials and also heat treatment, but he had not mentioned possible failures through retained austenite. This was one factor that should be impressed on people doing heat treatment, so that it might be prevented or overcome if it occurred.

Mr. Comley said that he had thought about retained austenite until he had begun to look at some "micros" showing minute quantities of retained austenite in tool steel, and had then decided that it would be difficult to illustrate it. He had referred to the question of double tempering, which was primarily designed to take care of retained austenite. The latter feature manifested itself in two ways. If it was ready to change, one would get a change to the hardened state, which was undesirable. If it was fairly stable it would have a reverse effect and probably cause a punch to barrel.

He had really tried to avoid technical metallographic discussion, because unless one was intimately concerned with metallography it did not mean much. What did have meaning was what he had tried to emphasize—that it was necessary to follow most explicitly the heat treatment laid down by the steel manufacturer, because he knew all about retained austenite. It was his job to provide the information and often, according to the prevalent beliefs in the firm, one got a slightly different opinion of its importance, and of the method of treatment.

Much effort had been put into sub-zero work. He had tried sub-zero quenching on tool steels for cold-extrusion punches, but it did not seem to matter: they broke just as easily either way. It was probably something that required investigation more on a research-laboratory scale than on the average works-laboratory scale. Using double tempering should eliminate the problem. With the layout that he recommended, at least three tempers would be produced and these, between them, ought to take care of the retained austenite.

Mr. D. A. Oliver (B.S.A. Group Research Centre) said that, as retained austenite had been mentioned, he would like to sound a note of warning about final grinding. It was well known that it was possible to have a few ten-thousandths of retained austenite in high-speed steels and certain complex alloy steels, and if a final temper was not put on the tool there would be the risk of this very thin film transforming under pressure.

Carbide Segregation

Mr. Kirk (Samuel Osborn and Co. Ltd.) said that carbide segregation appeared to be one of prime importance in ensuring uniformity of properties, particularly in the larger sizes of tools. The cellular carbide form visible in a number of Mr. Comley's photomicrographs was a natural feature of the solidification of high-speed steels in particular, and also high-carbon/high-chromium types. It was only by a considerable amount of hot work that these networks could be broken up—modified and generally elongated, giving a more uniform appearance. It would follow, therefore, that in the larger sizes of bar which might be required for larger extrusion punches in particular, the amount of hot work applicable was limited, if only because, in the larger ingot size, usually the centre segregations were heavier, and there was a lower cooling rate in that portion. One helpful suggestion was to supply a suitably pre-shaped forging, so as to provide the maximum amount of work on the stem of the punch.

He fully agreed with the remarks concerning the requirements for quality control, and from this aspect, his organization provided specially selected and tested materials for such exacting demands.

Heat treatment was very important. He had been particularly interested in the references to retained austenite, also those in relation to grain-size and obtaining the maximum degree of toughness in the finished tool. His own organization had found that there was an advantage in heat treating high-speed steel tools in particular. These appeared to be the more favoured qualities recently and they had found that an advantage was to be derived by decreasing the hardening temperature by 20 or 30 degrees below that normally applied. This would retain a fine grain-size and allow a certain amount of latitude for any variations that there might be in the temperature communications of the heat-treatment furnaces and salt baths. The lower hardening temperature would also tend to give less retained austenite in the hardened tool. Tempering was vitally important and he usually recommended two, and preferably three, tempers—particularly a final tempering treatment after grinding.

New Methods of Heat Treatment

New methods of heat treatment were under investigation in the metallurgical field. There had been discoveries in this country in that direction, and various patents had been drawn up covering controlled transformation of tool steels by holding at intermediate temperatures during the hardening process, so as to obtain a more uniform martensite transformation, which was freer of harmful internal stresses. In the United States various processes had received prominence of late. One of these was the Bassett process, about which very little was known. It was understood that transformation within a magnetic field was one of its features. It was felt that further work on this type of treatment, combined with selection of the best possible quality of steel, should help to provide for the ultimate optimum condition in cold-extrusion tools. He also agreed with the need for full co-operation between the steel manufacturer and those operating cold forming processes. It was only by free interchange of data and continued research into the many fascinating aspects of the subject that the ultimate desired improvements would be achieved.

The CHAIRMAN said he imagined that when a punch was machined some coolant was used. Could this cause hydrogen pick-up, resulting in failure due to hydrogen embrittlement?

Mr. COMLEY said that in his paper he had made the statement that he had discussed the possibility of surface treatment on tools, and had said that his guiding rule was that nothing should be put on the surface if it could be put inside. This applied to hard chromium plating, which was the prime cause of hydrogen embrittlement. He had never known it to result from coolants. He would not say that it would not happen because these days, when he put a cold piece of steel in a lathe the temperatures sometimes got up around melting point, and there were hydro-carbons in the oils. He had often been asked about hard chromium plating of tools and he thought that in tools of the cold-extrusion type it was to be avoided because one was subjecting a highly strained piece of material to one of the things that could crack it very easily—hydrogen. It was not possible to avoid hydrogen in hard chromium plating and from the literature that had been put out about removing hydrogen from such things as $\frac{1}{8}$-in. diameter springs, it appeared that no one was really certain when it was removed. It became an even more difficult problem on 2-in. diameter punches, etc., so any operation on a tool which would in any way introduce hydrogen into the lattice should be avoided. If surface treatments were required, the case-hardening nitriding treatments should be used.

A SPEAKER said that it was fair to say that retained austenite was one of the major problems engaging the metallurgists in Sheffield today. Their endeavour, in the development of new tool steels, was directed to ensuring that the retained austenite would be transformed by high-temperature tempering, as distinct from any refrigeration process, which could be a rather difficult business and not always successful.

Reference had also been made to segregation in the 12 per cent chromium steels with 1.5 to 2 per cent carbon. Here again, it was hoped that by the application of the newer steelmaking techniques it would be possible to obviate to some extent the vicious pattern of segregation encountered in large ingots in this type of steel.

Mr. HUNDY (Steel Peech and Tozer) added that one point to remember about hydrogen was that it could arise during the corrosion of tools, and even if not obviously visible, produce spalling and cause trouble. There was evidence of this happening in cold mill rolls.

Sulfinuz Process

Mr. H. D. BUTTON (Kayser Ellison and Co. Ltd.) said that the Sulfinuz process had been mentioned by Mr. Morgan, who admitted that his paper had been prepared a long time ago, when no results were obtainable. Could he give any further information now?

Mr. A. E. WALMSLEY (R.O.F., Birtley) said that as yet no results were available.

Mr. COMLEY said that he had never used it on punches, but had used it for other cold-working operations. In his experience it was erratic in as much as on one particular operation which presented a very thorny problem it worked wonders, yet on a differently shaped tool it had the reverse effect.

Mr. L. R. HAWTIN (I.C.I. Metals Division) said that his metallurgical colleagues had always assured him that low-temperature treatment, at around 150° C. following the application of chromium was essential so far as hydrogen pick-up was concerned.

Several speakers had referred to vacuum-melted steels, but had only mentioned their availability or non-availability. What were the advantages, if any, of these materials?

Mr. COMLEY replied that at one time he had thought that by immersing a piece of steel in boiling water at 150° C., the hydrogen was removed, but, having read published data on this he had come to the conclusion that this was not necessarily so. He had seen tools that had been chromium plated and stress relieved, but nevertheless had broken in a fashion that could only be due to hydrogen embrittlement. He did not think that the answer was as categorical as was suggested.

With regard to vacuum-melted steels, if a cold extruder in Birmingham wanted a piece of 3-in. vacuum melted high-speed steel immediately, he could not get it. He would think that the advantages

were purity and cleanliness, but would leave that to a member of a steel manufacturing firm.

Mr. D. SETTLE (Jessop Saville Ltd) said that vacuum-melted steels were certainly cleaner, provided they were melted in the right way. He had in mind the right melting conditions. They would certainly have a better carbide distribution. As had been suggested, one of the greatest problems at the moment was the question of carbide segregation, both in high-speed steels and high-carbon chrome. It was felt that vacuum arc melting could give considerable improvement in that direction. In terms of mechanical strength, it was possible to obtain better transverse properties and greater strength.

It was true to say that it was not possible to obtain vacuum-melted steel at short notice. The manufacturers were not saying yet that it would give far better results on cold-extrusion punches. Frankly, at the moment they simply did not know. They expected and hoped that it would but felt that it would be foolish to say so at this stage. So far as hydrogen embrittlement was concerned, he thought that 150° C. was far too low. One ought to be looking for a temperature around 425 or 450° C. He had recently been concerned with some cold drawing where a cold die had been chromium plated in the bore. There had been a crop of unexplained failures, and definite improvement had been achieved by raising the baking temperature from 150 to 450° C.

Mr. D. A. OLIVER (B.S.A. Group Research Centre) said that, in hard chromium plating, most of the hydrogen went into the steel during the preliminary etching operation. That was when reverse plating was taking place. It was the dangerous period, so it was important that the hard chromium plating should be done by someone who knew what he was up to. It was a difficult matter because the lattice was jammed hard with interstitial hydrogen atoms and if one tempered too much this would produce a soft chromium plating which would have lower wear resistance. It was important to distinguish what was being gained on the one hand by tempering and what was being lost on the other in regard to hardness. Experience indicated that 450° C. was a sound figure. The first stage of hydrogen evolution would be over by then. There were actually three humps in hydrogen evolution when the hard chromium plated deposit was heated up to about 120° C., and marked softening of the deposit occurred if tempering was effected at 500° C. or 450° C. might be the better compromise.

Mr. J. D. MANTLE (Ministry of Aviation) referring to hydrogen embrittlement, said that although gas analysis might indicate that the hydrogen had been eliminated, the damage that it had caused had not.

He would like to know whether there was any reason why steam-heat treatment of tool steels should not be employed. It had certain advantages in drills. Had it ever been tried in punches for extrusion?

In the creep-resisting steels, vacuum-melted stock was a different proposition for machining from air-melted stock. Had anyone had any experience in machining vacuum-melted high-speed steels?

Mr. COMLEY said that it had always seemed to him that if one had a highly-stressed tool and hydrogen got into it, there could be some form of incipient cracking, which would not necessarily take place throughout the whole tool, until it was used.

Steam Heat-treatment

With regard to steam-heat treatment, he had done some work on the formation of oxide films by steam on punches, but it had not balanced out other variations which existed, as between casts of steel, etc.

Steel made by conventional means had behind it the advantage of many years of "know-how". He felt that it would be some time yet before vacuum-melted steel could be evaluated against such steels but theoretically it should show some advantage.

Mr. D. SETTLE (Jessop Saville Ltd.) said that vacuum-melted steels were inferior in machinability. He wondered whether there might be some confusion between vacuum-melted stock and some of the "super alloys" which could only be made in the vacuum furnace.

Mr. J. D. MANTLE (Ministry of Aviation) said that his experience had been with creep-resisting materials which had previously been made in the air-melted condition. They were now vacuum-melted and the difference was tremendous; so much so that the machine shops were almost at a standstill.

Mr. KIRK (Samuel Osborne and Co. Ltd.) said that he wished to refer to the effect of very heavy and rapid cold working on the temperature rise both in the billet and quite often in the surface layers of the cold extrusion tools. He had come across tools in high-speed steel which had suffered a fall in hardness such as to suggest temperatures up to 600° C. It would be thought that at these high temperatures lubrication would be suspect; it might be necessary to use alternative lubricants. It might be that only at high production rates did these increased temperatures apply. He would welcome any comment, because it was obviously important if one expected temperatures of this order to be attained, to know exactly what was required so that the tool materials could be designed to meet the demands.

Mr. MORGAN (R.O.F., Birtley) said that probably Mr. Walmsley could say more about it, but to his

Tool Materials for Cold Extrusion—Discussion

(*Continued from page* 206)

own knowledge the temperature of the component reached about 120° C. It suggested, of course, that the temperature at the working head of the punch would be a lot higher.

Temperature During Extrusion

Mr. Walmsley (R.O.F., Birtley) said that there was indications that the temperatures sometimes reached during extrusion were of the order of 800 or 900° C. He attributed many tool failures to this. He knew very little about it, but found that the carbide distribution greatly influenced the absence of cracks.

Mr. Comley said that he was very pleased to hear this because he had looked at quite a number of punches and the incidence of failure seemed to be very much like that which occurred in hot work punches, where such temperatures were experienced. It seemed to explain to a certain extent some of the success of the 18/4/1 molybdenum high-speed steels—perhaps a little more than the difference in mechanical properties. He could not be absolutely certain but he had gained that impression, and it was gratifying to note that Mr. Walmsley had found the same sort of thing. He had seen many punches in many firms and it was always the same, so it was fairly widespread. It might be interesting to know how far one could take this. If it was purely a question of the breakdown of the punch being due, in many cases, to cracks arising from heat, it was difficult to know what to do about it, because in the hot work industry one had a very finite tool life which was entirely fixed according to the working temperature. Normally the higher the working temperature the lower the tool life, and at temperatures of 800 or 900° C., the tool life could be very low. The problem had not been solved by the tool steel trade. There were now in existence new types of hot working steels, one contained a high percentage of cobalt and showed a very marked increase in life compared with the conventional high-speed steels, and it may be that work in that direction would be advantageous.

Mr. Kirk said that he had been interested to hear of a possible temperature of 800° C. It appeared extremely high and the thinking of his own organization was to some extent substantiated in that there was available a high-carbon/high-vanadium high-speed steel containing additional cobalt which had enhanced resistance to heat and thus high abrasion resistance.

He added that one further precaution might be taken to obviate these thermal stress failures. It was to pre-heat the punch. Actual operators might care to comment.

Mr. J. D. Mantle found it difficult to reconcile a temperature of 800° C. in operation on the one hand with Mr. Griffiths' statement in his paper. He would have thought that if the material was in that region no work hardening would take place.

Mr. Comley said that only the surface was at 800° C.

Mr. Mantle said that it was also the surface that was work-hardened.

Mr. Comley replied that this was so but that the work-hardening on a cold-extruded slug extended throughout the section. It was conceivable that there might be a drop in hardness on the surface but the section tiself was completely worked and there would only be a breakdown at a temperature of the order of 150° C. on a very severely work-hardened mild steel.

Dr. Wallace said that the average temperature produced in an extrusion operation could quickly be calculated from the extrusion load. Something greater than 90 per cent of the extrusion work actually appeared as heat and therefore, by taking into account the specific heat and density it was possible to calculate the actual temperature. Very high temperatures were produced around the regions of extensive distortion, particularly the inside of the corners during backward extrusion. Here the temperature rise could be very much greater than what one would want as an average value. It was a fact that it was possible to melt materials by cold extrusion. It had been done in the case of tin and lead, and there was no reason why it should not be achieved, with very high reductions, in the case of steel.

Phosphate Coating etc. for Cold Extrusion—Discussion

(*Continued from page* 189)

appeared normal. There was no suggestion of pick-up. It was only out of curiosity that he had looked at it.

Surface "Stretch"

Mr. Morgan, developing this theme, said that he had analyzed the surface stretch both externally and internally. In a hollow can, the stretch of the material in the walls went up to 1,700 per cent without breakdown of the phosphate lubrication. He did this sort of thing quite regularly, and out of the thousands of components processed every week, they had never seen a case of breakdown of the phosphate coating.

Mr. P. Granby said that in the United States they spoke of lubrication spread as being up to 27 to 1 on tool finish and gave the figure of 10 micro-inch.

FLOW-LINE PRODUCTION for Batch Work

Methods in use at the Paddington Green Works of
JAMES H. RANDALL AND SON LTD.

FLOW-LINE production methods are normally considered the speciality of the mass-production plants, but this idea has been dispensed with at the Paddington Green Works of James H. Randall and Son Ltd. where flow-line techniques are applied to batch work. Presses, press brakes and spot welders form permanent features of the lines and additional spot welders, drilling machines and other equipment are moved in and out of the line as and when required.

The first of these lines, Fig. 1, comprises a 10-ton press for notching work, a 100-ton Craven press, an 8-ft. Rushworth 80-ton press brake, a 12-ft. Armstrong 100-ton press brake, a 60-kVA Metro-Vick spot welder and any equipment that may be needed for a particular job. The machines are arranged facing each other with a long table in the gangway between. In this way, minimum handling is required whatever the sequence of operations and a component is replaced on the floor a minimum number of times once the blank has been picked up.

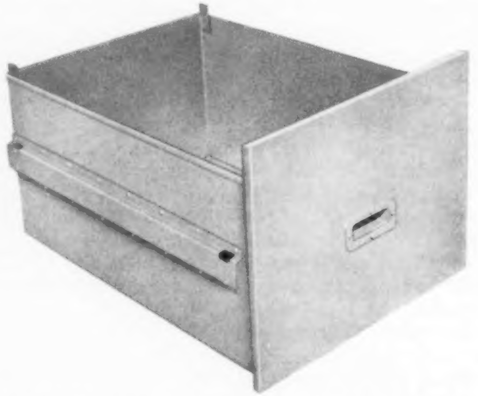
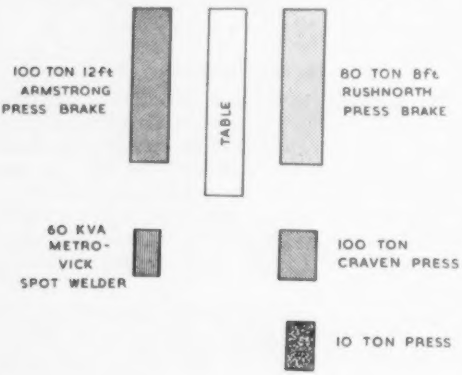


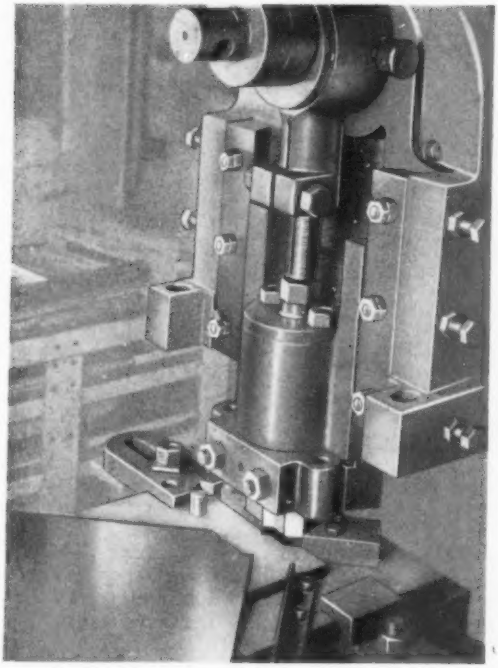
Fig. 2.—A six-part aluminium air-tight fitting drawer produced using flow-line techniques at James H. Randall and Son Ltd., although the quantities required are in the batch classification

Fig. 1.—Plan of the layout adopted for the first line. The machines are arranged facing each other with a long table between them. Another line similar to the first is installed and both are used mainly for sub-contract work



A second line is arranged in the same way with similar machines. This is preferred to having one big line since it is possible to keep production balanced and machine utilization at a high level. Various components for a given product can be processed to converge simultaneously at the assembly area.

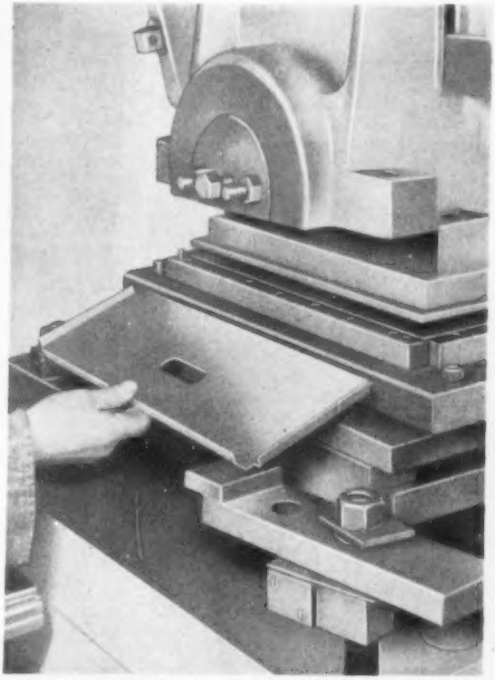
Non-conformity of approach is also evident in the design of press tools and very little use is made of standard parts. Tool design is dictated by the job in hand and every effort is made to include as many operations as possible in one tool. Although little use is made of standard parts, considerable use is made of old outdated tools; for this purpose a record is kept and once the main requirements for a new job have been decided, suitable redundant tools, that can be rebuilt, are utilized.



Sub-contract Work

The two main production lines are used predominantly on sub-contract work. Material is guillotined to size in a separate department adjacent to the material store. It is then fed to either of the two lines or to separate production facilities where the range of Randalrak, Rigirak, Planstore, Ranplan, and other standard equipment is made. Some of the work for these units is done on the lines, but by far the biggest percentage is sub-contract work with batch sizes varying from 50 to 7,000 components.

A special air-tight fitting drawer, Fig. 2, recently progressed through Randall's workshops provides a good example of the application of their approach. The drawer is made up from six major components : the main body, two runners, the back and the



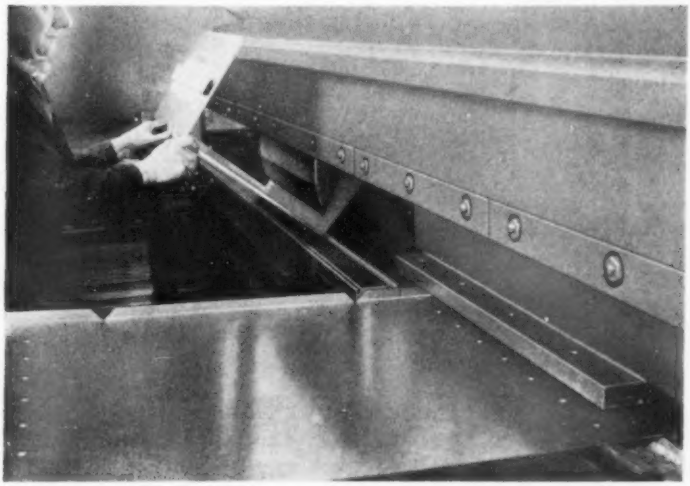


Fig. 3 (top left).—A ten-ton press included in the first line for notching work. The general order of the machines is relatively unimportant as the sequence of operations varies from job to job

Fig. 4 (centre).—Punching and forming the outer member of the drawer-front is carried out in the second line. The size of the second line is such that the flow of work to the assembly shop is balanced thus reducing the length of time the job is in the shop.

Fig. 5 (left).—First tool on the press brake rivets runners in place after runners and rivets have been loaded

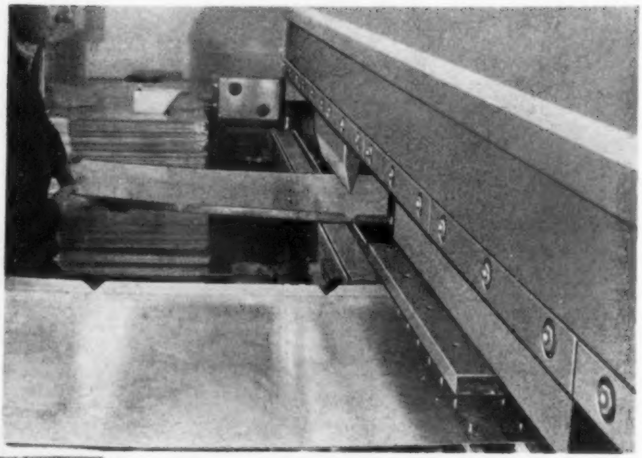
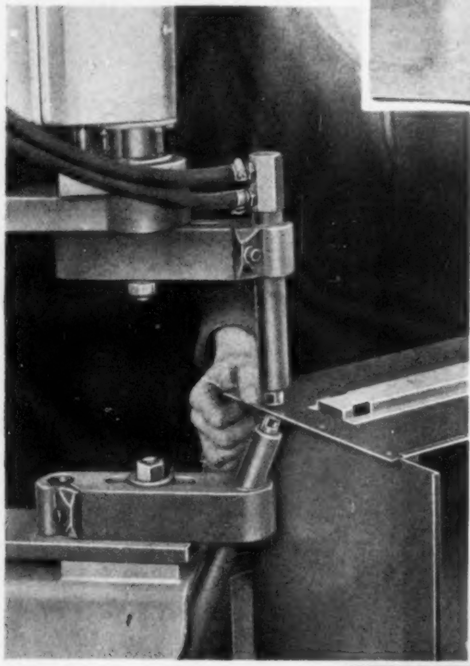


Fig. 6 (right).—The second tool folds the main body sides



inner and outer members of the front. Material throughout is 16-s.w.g. aluminium except for the runners which are from 16-s.w.g. steel.

The first part to be started is the runner. The cut blank is received from the guillotine shop and two rows of holes are punched in each runner on a press brake. This is followed by punching two square holes in one end on one of the presses and two profiled holes in the other end on the second press. Finally the flat strip is formed in the second 100-ton press to obtain the top-hat shape that can be seen in the illustration of the complete drawer.

The runners are made first so that the centre distance of the two rows of holes can be measured after forming, and stops on the press brake set to this dimension. The oblong blank for the main body is then taken and two sets of double-row holes are

(*Continued in page* 222)

Fig. 7 (above).—The back and inner front members are spot welded to the main body by the Metro-Vick 75-kVA in the assembly shop, where parts converge from the two separate lines

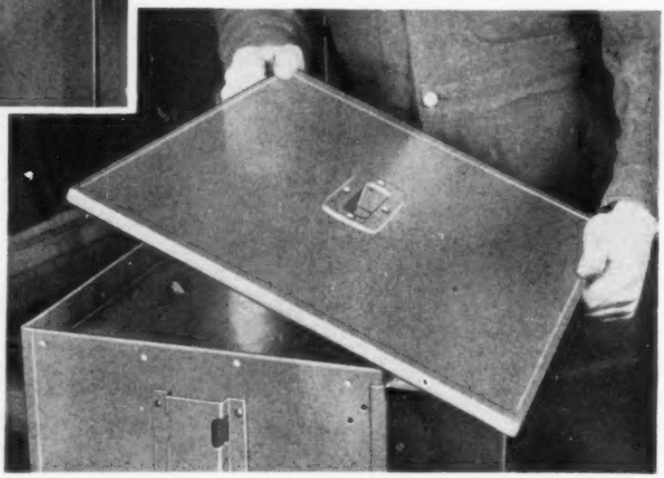


Fig. 8 (right).—The outer front member is hooked over the inner member top and secured in place with five PK No. 8 self-tapping screws through the bottom flange. Finally, runner rollers, and stops, are fitted

An Introduction to the

THEORY AND PRACTICE OF FLAT ROLLING—7

By the late C. W. STARLING, B.Eng., A.M.I.Mech.E.

(*Continued from page* 146, *February*, 1961 *issue*)

THE MEASUREMENT OF ROLLING LOAD AND TORQUE

IN the previous discussions on the forces on the material, the rolls and the housing, the roll load has entered into every calculation and is probably the most important single factor in the design and operation of a rolling mill. When designing a mill, the first essential is for the customer to specify exactly the work to be done on the mill. From these requirements the rolling load for the various rolling schedules is calculated as accurately as possible and the mill designed for the appropriate safety factor on the loads obtained from the calculations. Many methods of calculating rolling load have been suggested, some of which are more accurate than others, but all are alike in their complexity and all depend on an accurate knowledge of the coefficient of friction. Probably the most widely accepted method of calculation of load and torque in hot rolling is that due to *Sims* and in cold rolling to *Ford* and *Liania*.

The measurement of roll force on a production mill has a great many uses apart from the obvious one of indicating to the rollerman when his safe limit of load has been reached. It has already been shown that the roll cambers are very important and the exact camber required to give a flat strip can only be obtained at one specific rolling load. At any load less than this, the camber will be too great to compensate for the roll bending and this will result in a loose middle to the sheet and similarly, if the roll load is too great, the camber will be insufficient to compensate for roll bending and the strip will have loose edges. If the mill is fitted with a roll-load measuring device, a table can be drawn up showing the correct load for a given reduction on a particular width of sheet. This is normally found by rollermen by experience and by trial and error, but if such a table could be obtained from accurate roll load readings, it should be possible for a mill manager to survey the rolling schedules and arrange the pass reduction for each width to give maximum production and to suit a standard set of roll cambers. Any slight errors in camber can be compensated for by differential water cooling of the rolls.

There is a further important use for load meters in a production mill and that is to help scientists and research organizations in their work on rolling theories. All scientific work carried out in laboratories must necessarily make use of small mills, and in rolling particularly, it is not always possible to adapt results obtained on small low-speed mills to high-speed production units. Accurate load measurements taken from production mills under a variety of conditions will, therefore, give invaluable assistance in checking rolling theories.

The use of rolling torque has not been so evident in previous chapters, but it is obviously essential in designing a rolling mill. The power required for various pass schedules and speeds will be calculated from the torque and all the detailed design, such as the size of the roll-neck and drive details will depend on the torque. The rolling torque can be calculated in any of several ways, but again is dependent on the coefficient of friction. It is not easy to measure the actual torque required for the deformation of a bar between the rolls, as the roll-neck bearings are very heavily loaded and a substantial torque will be required to turn the roll neck in the bearing. This is particularly the case in the old-type mills running on brasses, when the roll-neck-bearing torque may be greater than the actual rolling torque. Measurement of the torque input to a mill is not a great deal of help to the rollerman, as he is more interested in the load on the motor drive and in practice, it is usually sufficient for the rollerman to have an indication of the current in the main motor. When drafting very heavily in a slabbing mill, it is quite usual for the main motors to hesitate and even stop momentarily as the ingot enters the rolls. The motor current will often show an overload, and as the speed drops, the torque will reach a very high value and an actual measurement of torque on the input shaft would be a help in this case. Again, measurement of torque under production conditions would be a great help to scientists.

Methods of Load Measurement

The requirements of a roll-force-measuring device are :—

(1) It must be simple.
(2) It must be accurate.
(3) It must have a fast response to enable transient load conditions to be seen.
(4) It must not require a great deal of maintenance.
(5) It must not be sensitive to temperature changes.
(6) It must not increase mill spring.

There are two ways in which the problem of roll-force measurement can be tackled. The first is to make use of one of the existing stressed members of the mill and the second is to add a separate unit.

Various attempts have been made to use the stressed components of a mill to measure the rolling load, but none have been very successful. The obvious place to attempt to measure the rolling load is on the mill housing. Although the stress in a housing post of a conventional mill is small, there is a considerable length to give a measurable change in length under load. If it is assumed that the posts are under a direct tension due to the rolling load, it is possible to measure the stress by various mechanical or electrical means. It has already been shown, however, that there is also some bending of the posts under load, which would affect the calibration of the load-measuring device. There are also subsidiary forces due to end thrust on the rolls, binding of the chock in the guides, twisting of the chock, etc. Neglecting all these errors, it is possible to use a simple mechanical system to measure the extension of the post under load. A long bar anchored at the bottom of the post and left free to move at its top end can operate through a lever system attached to the top of the post to move the pointer over a graduated scale, as shown in Fig. 123. A similar principle can be used with a hydraulic measuring device replacing the mechanical lever linkage. A rather more accurate method is to use a bar attached rigidly at both ends and measure the change in length by any one of several electrical methods, the most common being change in resistance. Load-measuring devices such as these have been in use for many years, but have never become popular because of the difficulty in maintaining the accuracy and the difficulty in obtaining the initial calibration.

Another possibility is to measure the change in length of the screw to indicate the stress in the screw and hence the rolling load. As far as can be ascertained, this has never been done, but there is no obvious reason why it should not be possible to drill a hole through the axis of the screw and insert a rod which would be attached rigidly to the bottom end of the screw, the remainder being free, as shown in Fig. 124. There are then several methods by which the difference in length between the rod and the screw could be amplified and used as an indication of rolling load. The weakness of this is that the free length of the screw is constantly varying and hence the calibration would not be constant. It should be possible to add an electrical signal to correct the calibration for the free length of the screw, but this would add to the complication of the device and increase maintenance costs.

It is just conceivable that the rolls themselves could be used to give an indication of the rolling load. In a four-high mill a measurement taken across the two diameters of the back-up and work roll at one end of the barrel would indicate the amount of flattening between the work roll and its backing roll under the rolling load. Mechanically, this would be rather cumbersome and there would be many detailed design difficulties, in addition to which, the calibration would be non-linear. There would also be substantial differences in the zero setting because of variation in roll temperature and because of roll wear.

In the case of a hydraulically loaded mill the problem is simple as a measure of hydraulic pressure is sufficient to give a good indication of the rolling load.

The most satisfactory method of measuring rolling load now appears to be to introduce a self-contained load-measuring unit into the system. There are two possible locations for a unit of this nature, one being between the screw and the top chock and the

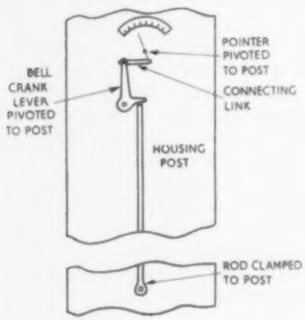
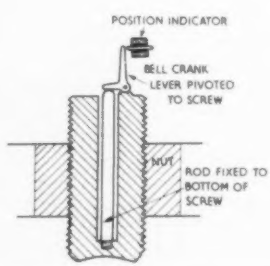


Fig. 123 (*left*).—*Diagram showing the principle of a simple lever amplifying system for measuring mill housing strain*

Fig. 124 (*right*).—*Diagram showing the principle of a lever amplifying system for measuring strain in a mill screw*



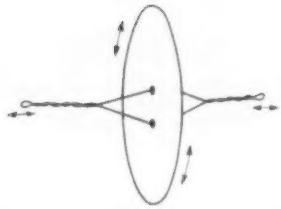
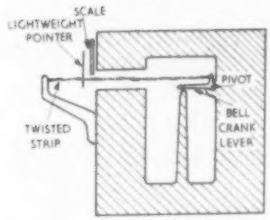


Fig. 125 (left).—Rotating disc on a twisted string. The principle of the Mikrokator

Fig. 126 (right).—Load meter working on the Mikrokator principle



other between the bottom chock and the housing. In existing mills, it is impossible to fit the unit below the bottom chock and the only remaining place is between the screw and the top chock. This complicates the mechanical design, as the load-measuring unit must have a bearing, under extreme pressure, which rotates with the screw and in most types of measuring device it is essential that no twisting action be transmitted from the screw to the body of the unit.

In order to keep the mill spring to a minimum, the roll-force-measuring unit or load meter, as it will now be called, should as short as possible and should be a solid steel block. The problem is then to measure an extremely small change in length of this cylindrical block or a section of this block.

There are many ways of measuring this change in length and they can be grouped into :—

(1) Mechanical.
(2) Electro/mechanical.
(3) Hydraulic.
(4) Electrical, which can be sub-divided into the measurement of resistance, capacity, electro-magnetism and several other lesser known ones.
(5) Optical.

Taking these various methods in the order given :—

(1) A purely mechanical system could be made up by using a hollow cylinder for the main body of the unit with a delicate lever system to amplify any change in length of the block and indicate it on a scale attached to the outer circumference of the block. This is not really a practical proposition except in the case of a very large unit.

There is, however, an interesting load meter working on purely mechanical principles which is designed and marketed by C. E. Johansson Ltd. This is based on the Mikrokator amplifying mechanism. The principle of this can be seen from the simple toy consisting of a disc with two holes in the centre mounted on two pieces of string. The disc is twisted to wind up the string and it can then be kept rotating, first in one direction and then in the other by alternately pulling and releasing the ends of the string, as shown in Fig. 125. Similarly, if a thin ribbon of steel is twisted and held securely at each end, any variation in length between the supports will cause the ribbon to twist a little. The rotation of the centre portion of the strip in relation to the change in the distance between the supports is a function of the physical properties of the strip, the dimensions and the pitch of the twist. A graph can be plotted showing the relationship between the rotation at the centre of the strip and the change in length between the supports and over the normal working range this is a straight line relationship. This mechanism can be made extremely sensitive by using suitable strip and a light-weight pointer and it is not at all unusual to have a mechanical amplification of more than 5,000 to 1. By the use of a simple lever system at one end of the supports, it is easy to obtain a further 10 to 1 amplification, giving an overall amplification of 50,000 to 1. In this type of mechanism it is essential that the pointer is as light in weight as possible and as small as possible in cross-section. The mechanism is so delicate that the effect of air damping on the pointer can be quite pronounced and in order to obtain a very rapid response the pointer must have a very low inertia, otherwise the periodicity of the pointer will be lower than that of the system. It is usual to use a tapered glass tube, with a diameter of only a few thousandths of an inch at the large end and this has a tip of Duralumin to make it easily visible. A possible application of this principle to a load meter is shown in Fig. 126. This consists of a hollow steel cylinder with a central rod attached to the bottom of the load meter. This rod bears against the end of a ball crank lever, which forms one support for a Microkator strip, which is attached at the other end to a fixed support mounted on the side of the load-meter block. The pointer then registers load directly on a scale mounted on the side of the load-meter block. This can be a very accurate instrument and has been used with some success on small rolling mills. It is, however, a little too delicate for general production use.

(2) Various electro-mechanical methods of measuring the change in length of a load-meter unit have been developed and there is one which is available from Boulton and Paul Ltd. This consists of a hollow steel cylinder with a peg attached to one face. Any change in length is picked up by a lever system, amplified, and turned to give a horizontal movement to a rod which forms the core of a

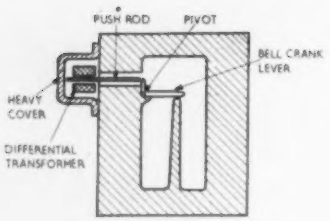
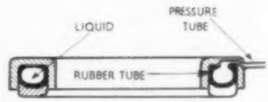


Fig. 127 (*left*).—*Diagram showing the principle of the Boulton Paul load meter*

●

Fig. 128 (*right*).—*Diagram showing the principle of the Statimeter*



differential transformer. The principle of this load meter is shown in Fig. 127. The differential transformer is now well established as a means of measuring small displacements and consists of a cylindrical former with a primary winding and two secondary windings. A soft-iron core can move along the axis of the transformer and at a given zero position of the core, the voltages induced in the secondary windings by a given primary voltage are equal in magnitude and can be connected together to cancel out. Any movement of the core from the zero position then increases one secondary voltage and decreases the other, giving an output voltage which is proportional to the displacement of the core. This linear relationship is accurate for small movements only and these instruments are made commercially to cover various ranges, the most sensitive one which is freely obtainable having a linear range of 0.050 in. In general, the higher the frequency of the applied voltage, the faster is the response of the system and an accuracy of about plus or minus 1 per cent is claimed. The differential transformer is not yet quite sensitive enough for direct measurement of the variation in length of a load-meter block, but when amplified mechanically by a simple lever system, as shown in Fig. 127, they form a simple and robust measuring system.

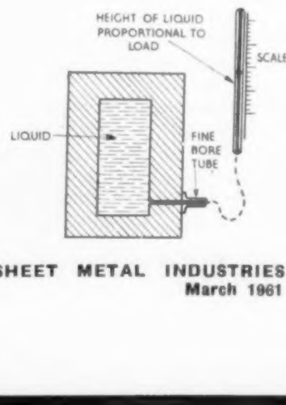
(3) Various hydraulic load meters have been developed and sold under different trade names, but as yet none of the hydraulic ones have become popular for rolling-mill use. Perhaps the best known one is the Statimeter, which is used extensively for measuring the thrust of jet engines and for similar work in testing thrust from compressors. The principle of the Statimeter can be seen from Fig. 128. A ring-shaped rubber tube is held in an annular recess and applies pressure to the rubber tube, which is filled with an incompressible mixture of glycerine and water. When pressure is applied, some liquid is displaced *via* a capillary tube to a Bourdon-tube-type pressure gauge. These instruments have been used with a great deal of success under carefully controlled conditions, but they are hardly robust enough for rolling-mill work.

There is another type of hydraulic gauge, which has been made in small units for various purposes and which could possibly be adapted for rolling-mill work. This consists of a heavy steel cylinder filled with an incompressible fluid, with a capillary leading to a small-diameter measuring tube, as shown in Fig. 129. When the main cylinder is compressed under load, fluid will be expelled and rise up the measuring tube. The distance it moves up the tube will be amplified from the movement of the main cylinder by a little less than the ratio of the diameters of the cylinder and the measuring tube. This is very simple and robust enough for rolling mill work. It can be made very heavy, so that it has little effect on mill spring, but the chief disadvantage lies in the high temperature coefficient. It will be seen that the major difference between the two types of hydraulic units mentioned lies in the fact that in the first case the hydraulic fluid is under pressure and it is the pressure which is used as the measuring medium, whereas in the second one the fluid is under atmospheric pressure only and it is the movement of the fluid which is used to obtain the load measurement.

(4*a*) The electrical-resistance strain-gauge load meter is the only type which has been used extensively in production rolling mills. This was developed by BISRA and taken over commercially by Davy and United, who make them in all ranges up to 1,500 tons. Although on the face of it this type of load meter appears to be quite simple, it did in fact require a great deal of development before becoming a commercial proposition. The basic design has now been described many times in the literature, but for the sake of completeness, the principle will be given here.

The load-measuring element is a solid cylinder of high-tensile steel which carries a net-work of electrical-resistance strain gauges bonded to its surface to measure the compressive strain in the block. The length/diameter ratio of the cylinder is important, as in practice it is not always possible to ensure that the load is truly axial or that it is evenly distributed across the face. If the length/diameter

Fig. 129.—*Diagram showing the principle of the hydraulic displacement load meter*



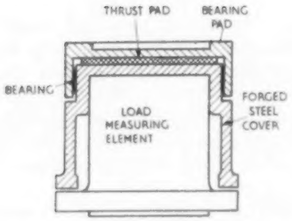
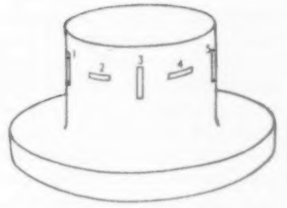


Fig. 130 (left).—The strain-gauge load meter

Fig. 131 (right).—Diagram showing the arrangement of strain gauges on a load meter



ratio is large so that the strain gauges are a comparatively long way from the loaded face, any slight unevenness in the loading will have little effect on the strain distribution of the gauges. It has already been pointed out, however, that mill spring should be kept to a minimum and this implies the shortest possible load cylinder, so that, as in most things, a compromise must be reached. In fitting load cells to existing mills, it is usually found that the space available is limited and this fixes the overall height of the loadmeter. By careful mechanical design which eliminates uneven loading as far as possible, an accuracy of plus or minus 1 per cent can be obtained with a length/diameter ratio of unity. It is very difficult to obtain this degree of accuracy if the ratio drops to less than 1.

A typical strain-gauge load-meter design is shown in Fig. 130. The choice of material for the main load-measuring element is important, as it must remain completely elastic at the maximum designed stress and should always produce the same strains on loading and unloading. A heavy forged-steel cover provides mechanical protection for the sensitive strain-gauges and also transmits the torque of the bearing cap to the chock. Care must be taken that the cover cannot possibly touch the flange and take some of the load. A bearing cap rotates on a phosphor-bronze insert and the thrust pad of phosphor-bronze or a laminated fabric.

The strain gauges are mounted on the measuring cylinder, as shown in Fig. 131. The vertical gauges measure the compressive strain and the horizontal ones are primarily used as temperature compensation. Due to the hoop tensile strain, however, the horizontal gauges will actually measure a slight tension and will, therefore, increase the total reading on the Wheatstone Bridge circuit, shown in Fig. 132. This is the simplest possible arrangement and if a d.c. voltage is applied across the bridge, the reading of a microammeter will indicate the extent of the "out of balance" of the bridge, due to the compression of the measuring cylinder. The deflexion of the ammeter can then be calibrated directly in tons load.

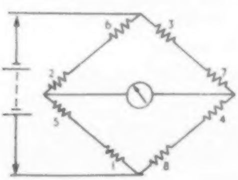
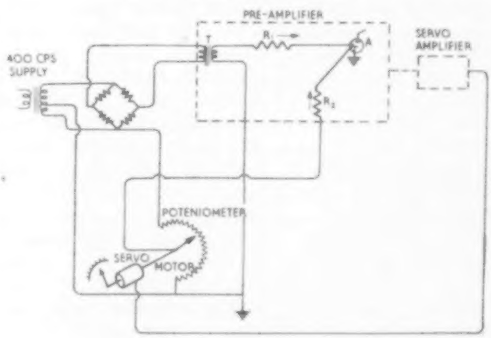


Fig. 132 (left).—Diagram showing the arrangement of load-meter strain gauges in a Wheatstone bridge

The a.c. potentiometric indicating circuit is the one most commonly used in practice for rolling mill instruments and the principle of this is shown in Fig. 133. The strain gauge bridge is supplied with a.c., usually at about 400 cycles per sec., and instead of reading the output from the bridge by a microammeter, it is transformed to a higher voltage at T. This voltage is compared at point A with a voltage obtained from the input supply and adjusted by a circular potentiometer. When the bridge is in balance, the potential at point A is zero, but when out of balance the resultant voltage at A is amplified and operates a small servo motor, which drives the potentiometer in the appropriate direction until a balance is reached. The angular position of the potentiometer is then an indication of the out of balance of the bridge and can be calibrated directly in tons. This has the advantage for rolling-mill work that the pointer is mechanically driven from a small servo motor and can be made to any size required and mounted in any convenient position.

(4*b*) There are available various instruments which measure small linear movements by means of the change in capacitance of a parallel plate condenser. Attempts have been made to incorporate this principle in a loadmeter, but without any real success. Very briefly, the linear movement to be

Fig. 133.—Diagrammatic arrangement of a more advanced load-meter strain-gauge circuit



measured is transferred to the two plates of a parallel plate condenser and the change in capacitance, due to the change in spacing of the plates, is measured. The difficulty here is that to obtain an accurate reading, the plate spacing should be large compared with the displacement to be measured, as the capacitance does not vary in a linear manner with the movement of the plate. The capacitance is very sensitive to changes in temperature and it is difficult to compensate electrically for these changes.

(4*c*) It was thought at one time than an electromagnetic gauge may be suitable for development, but to obtain an accuracy comparable with the electrical-resistance strain-gauge load-meter requires a much more complicated design, both electrically and mechanically. The principle of this type of gauge is simple and normally a small ferrous armature is located in a magnetic path, which is completely closed except for a small air gap on each side of the armature. Inductance coils are wound on the two limbs of the magnetic circuit adjacent to the armature and deflexion of the armature alters the air gap, so affecting the inductance of the coils. This type of gauge has been described at some length by *Ford* and others.

(4*d*) There are available commercially several types of variable-inductance transducers for measuring small linear movements. Usually a magnetic core moves inside two coils and causes a change in the reluctance of two magnetic circuits. An accuracy of 1 per cent is claimed, but as far as can be ascertained, this principle has never been applied to the measurement of load.

(5) An ingenious optical method of measuring load has been suggested by *Jennings* and a small prototype unit built. This worked well in the laboratory and an accuracy of $\frac{1}{2}$ per cent was obtainable. This instrument could probably be adapted for laboratory rolling-mill measurements, but is not robust enough for commercial use.

A beam of light from a standardized source was passed through a filter made up from two glass plates and picked up by a photoelectric cell which provided an electrical signal proportional to the intensity of the light. The filter was made up of two identical glass plates each having parallel vertical lines, giving alternate black and clear marks on the plate. A line width of 0.005 in. alternating with clear glass spaces of 0.005 in. was used on the prototype. If the two identical plates are positioned so that the black lines coincide, the transmission of light will obviously be 50 per cent of that which would be passed if the glass plates were clear. If the plates are now moved slightly relative to each other it will be seen that the condition will be reached when the light will be blanked off completely. The light passing between these two extreme conditions will then depend on the relative position of the plates. By designing a load meter incorporating these two glass plates, it is possible to arrange a mechanical system which amplifies the strain in the load meter to move the plates relative to each other. By a suitable choice of line width on the glass plates and of lever systems, this type of instrument can be used to measure a wide range of linear movement.

This method of measuring linear movements and hence loads, is given as a matter of interest rather than as a serious method of producing a commercial load meter and there is no point in describing a load meter incorporating the optical grating in any detail.

Methods of Torque Measurement

The requirements of a torque-measuring device are identical to those given for the load meter, except that instead of the criterion that it should not effect mill spring, should be substituted that it should not effect the rigidity and torsional stiffness of the shaft at which the torque is being measured. It is not immediately obvious why it is necessary to make a direct reading of the torque and for this reason torque meters have not yet been used extensively on production mills. It is usual to have a reading of main motor current and from this it is a simple matter to calculate the torque output of the motor. It has been found, however, that the torque is by no means equally distributed between the two spindles and in actual fact readings have been taken in which one spindle was carrying the full rolling load and the other spindle has had zero torque and in extreme cases a slight negative reading. Very little is known about this phenomenon and it can only be assumed that it is due to differences in frictional condition between the two rolls. For this reason mill operators are now beginning to consider the advisability of torque meters, particularly on highly-stressed spindles, subject to shock load, as in a slabbing mill.

As with the load meter, the various methods of measuring torque can be split up principally into electrical and mechanical. All methods basically measure the twist in the shaft over a measured length and use the straight line relationship between the angle of twist and the applied torque to calibrate the instrument directly in lb.-ft., or ton-inches, in the same way as the load meter actually measures the compression in a steel block and makes use of the straightline relationship between compression and applied load.

If r = radius of shaft in inches.

θ = angle of twist in radians, in a length of L.

T = torque in ton-inches.

C = the rigidity modulus in tons per square inch = approximately 5,000 tons per sq. inch for steel.

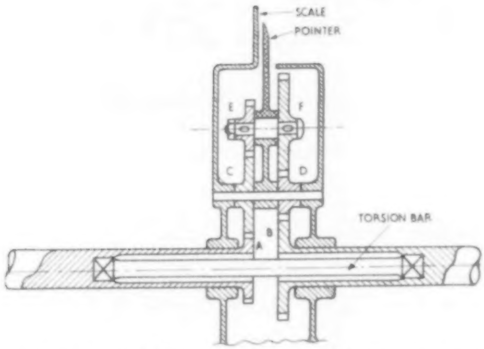


Fig. 134.—Arrangement of an epicyclic torque meter

Then the relationship between the applied torque and the angle of twist is given by

$$\theta = \frac{2.T.L.}{\pi\ C.r^4}$$

There are many mechanical methods of measuring θ in this equation, but few can be applied directly to rolling mill spindles, as the space between the two spindles is usually limited. There is, however, a Patent, which appears to be very suitable for heavy rolling-mill spindles. The principle of this is shown in Fig. 134. Gear wheels A and B are attached to the two halves of a shaft which are joined together by a torsion bar. These gear wheels mesh with gears C and D, which are mounted co-axially, but which are free to rotate independently of each other. These in turn mesh with gears E and F, which are keyed to a common spindle, carried in a framework which is free to rotate about the same axis as gears C and D. When the two halves of the shaft are rotating at the same speed, all the gears are rotating, but the carrier on which the pointer is mounted remains stationary. If, however, there is relative movement between the two halves of the shaft, the framework which carries the pointer will move, the distance it rotates being directly proportional to the angular movement between the two halves of the shaft.

This type of torque meter can easily be designed in a robust fashion to withstand the conditions obtaining in rolling mills and as the gears revolve, but do not transmit any load there should be little maintenance required. Some modifications will be required to suit existing rolling mill spindles, as it is not usually convenient to cut the spindle and insert a torsion bar. It is also usual to keep the designed stress in a spindle to a low value to cater for shock loading and the torsion bar would form a weak link and probably require replacing at frequent intervals. It should, however, be possible to adapt this design to enable it to be attached to existing spindles, if necessary without removing the spindles. Fig. 135 shows one way of attaching the gears to a shaft, working on a known gauge instead of a torsion bar, and if necessary, they could be made in halves and clamped in position on the shaft.

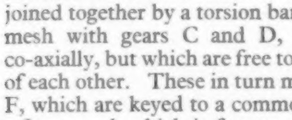


Fig. 135.—Diagram showing method of mounting the first gears of an epicyclic torque meter on an existing shaft

It is a simple problem in epicyclic gearing to calculate the angular movement of the pointer for a given torque, but it is advisable to calibrate the scale by direct measurement. This can be done statically by clamping a lever on the shaft and hanging a series of known weights on the arm. The arm must, of course, be kept horizontal or an allowance made for any angular movement of the arm.

Several electrical methods of measuring torque have been suggested and used, but the only one which is being produced specifically for rolling mills makes use of the electrical resistance strain gauge. The strain gauges are so arranged that the change in length of a line on the surface of the shaft at 45 deg. to the axis is measured.

The maximum principal strain in a shaft is at 45 deg. to the axis and if l is the length of the strain gauge set at this angle and δl is the extension of the gauge under load, the torque can be obtained from :—

$$T = \frac{\delta l.\ \pi.\ C.\ r^3}{\sqrt{2}.\ l} \quad \ldots \quad \ldots \quad \ldots \quad (27)$$

where T is Torque in ton.-in.
r = radius of shaft in in.
C = rigidity modulus (ton per sq. in.)
= 5,000 ton per sq. in. for steel.

As usual, the strain $\frac{\delta l}{l}$ is measured by means of a number of strain gauges in a Wheatstone-Bridge net-work. In practice, it is virtually impossible to ensure that a shaft is in pure torque and almost always there will be some degree of bending. The gauges must, therefore, be mounted in such a fashion that errors due to bending are cancelled out. Pairs of gauges mounted and connected up, as shown in Fig. 136 will give this correction. If the shaft bends slightly around the axis AA, gauges Nos. 1 and 2 will increase in resistance by the same amount as gauges 3 and 4 decrease and the output of the bridge will be unchanged. Similarly, at any other angular position, strain due to bending will cancel out between the two sets of gauges. The mounting of the gauges and protection against moisture and mechanical damage is of the utmost importance and should be carried out by specialists experienced in this class of work. The arrangement

(*Continued in page* 218)

TWO-DAY SYMPOSIUM ON "COLD-FLOW FORMING"

A two-day Symposium on "Cold-Flow Forming" will be held at the Wolverhampton and Staffordshire College of Technology under the aegis of the departments of applied science and production engineering; the chairman will be R. A. P. Morgan, O.B.E., M.I.Mech.E. (Superintendent, R.O.F., Birtley). The fee for the Symposium is £1 1s. and further details may be obtained from the College by writing to the Course Organizers, G. R. Morton, F.I.M., and H. Southan, L.I.M.

PROGRAMME

Thursday, March 9, 1961

10.45 a.m.	Introduction by Chairman.
11.00 a.m.	The Cold Extrusion of Steel. (R. A. P. Morgan, Esq., O.B.E.)
12.00 noon.	Discussion.
	LUNCH
2.15 p.m.	The Cold Extrusion of Metals Under Impact Conditions. (M. T. Watkins (National Engineering Laboratories, East Kilbride)).
	TEA
3.30 p.m.	Discussion.
4.00 p.m.	The Replacement of Forgings by Cold Flow Forming. (F. Griffiths (British Motor Corporation, Birmingham)).
5.00 p.m.	Discussion.

Friday, March 10, 1961

9.30 a.m.	Opening Remarks by Chairman.
9.40 a.m.	Metallurgical Aspects of Cold Flow Forming. (R. Okell (Forgings and Presswork, Ltd., Witton, Birmingham)).
10.40 a.m.	Discussion.
11.00 a.m.	COFFEE
11.15 a.m.	Tooling for Cold Flow Forming. (W. S. Ketchin (Royal Ordnance Factory, Birtley, Co. Durham)).
12.15 p.m.	Discussion.
	LUNCH
2.00 p.m.	General Discussion.
3.30 p.m.	Summary and Concluding Remarks by Chairman.

Theory and Practice of Flat Rolling

(*Continued from page* 217)

of the gauges and the Wheatstone-Bridge net-work presents little difficulty, but the problem of supplying the voltage to the bridge and taking off the ammeter current is a major one. Some type of slip-ring gear must be used, but as the currents involved are in micro-amp., and the changes in current are extremely small, the slip-rings require careful designing. The critical factor is the choice of materials for the actual slip-rings and the pick-up brushes. The contact potential and resistance must be small and constant over a wide range of rubbing speeds and the background "noise" induced by the contact in an amplifying system must be as small as possible. It has been found after testing many combinations of materials that silver slip-rings and soft carbon brushes give excellent results. Although the contact potential of this combination is higher than many others, the variation with speed is low. The noise level is low, apparently because of the lubricating action of the soft carbon brushes, which prevent localized heating.

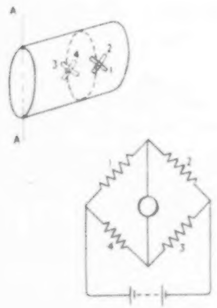


Fig. 136.—*Diagrams showing the arrangement of strain gauges with correction for bending in a strain gauge torque meter*

Although an accurate calibration can only be made by scaling the meter directly from a static test with a torque arm and weights, it is possible to calculate an approximate calibration factor. This is carried out in a similar fashion to that for a load-meter, but is a little simpler as the strain is the same in all four gauges. Both calculations can be obtained from published papers by the author.

(*Series to be continued*)

SHEET METAL DATA SHEET 15

Manufacture of Tin Boxes—3

Compiled by J. W. Langton, M.B.E., B.Sc.(Lond.), M.I.Mech.E.

CIRCULAR CONTAINERS WITH SIDE SEAM

THESE containers are in very common use, including those in the sanitary can range (*i.e.*, packed foods, etc.), containers for paints, powders and so on. All containers covered in this data sheet have at least two seams, a side seam, and an end seam. Where the top is seamed, as in the sanitary cans there is a third top seam but there are several alternative types of top closure.

The side seam is mostly a lock seam, and the end seams are double seams.

TYPES

The types are usually distinguished by the form of top closure.

The sanitary or open-top can type has the top or end double seamed in.

The slip-lid type is self explanatory.

The lever-lid types have a cap fitting into some form of lever ring, of which there are a number of different forms.

Other common types such as screw lid, bottle container, etc., are obvious from their names.

The seams of containers to hold liquids have to be filled to make them liquid tight by solder or special compounds.

SIZES AND SUBSTANCES

Usually the maximum diameters do not exceed 8 in. and the general lengths are usually below 9 in. and the basic plants cover most of this range. The substances vary from 0.008 to 0.015 in., and the ones chosen are to suit the particular container strength required. The IX (0.015) is exceptional, and used for the largest sizes to carry fairly heavy contents, as paint.

Common English Sanitary Can Sizes are as follows:

	Dia. × *Ht.*		*Dia.* × *Ht.*
Picnic	211 × 302	A2	307 × 408
A1	211 × 400	E2	310 × 411
E1	301 × 400	A2½	401 × 411
A1 Tall	301 × 411	A10	603 × 700

The first figure is the inch size, the last two the fraction in sixteenths, *i.e.*, 301 is $3\frac{1}{16}$, 310 is $3\frac{10}{16}$ or $3\frac{5}{8}$.

Common English Paint Tin Sizes (B.S.I. Recommendation)

½ pint $2\frac{3}{4} \times 3\frac{5}{8}$ or $3 \times 3\frac{1}{4}$

1 pint $3\frac{1}{2} \times 4\frac{1}{2}$

1 quart $4\frac{1}{2} \times 5\frac{1}{4}$

½ gal. $5\frac{1}{2} \times 6\frac{1}{2}$ or $6 \times 5\frac{3}{4}$

1 gallon $7 \times 8\frac{1}{4}$

SELECTION OF TYPE

The type selection has to be of a container which will serve best to carry the contents safely and provide satisfactory access, and probably suitable re-closure during normal life of the container. There are a number of variables involved, and the right choice or otherwise can have a serious effect on the cost. The moral is that the selection has to be done with skill.

BASIC OPERATIONS

The basic operations for the container body, its end and base, and seaming on the end (*i.e.*, excluding considerations of top closure) are as follows:

(1) Cutting up sheets to provide blanks for bodies and strips for ends.
(2) Notch body blanks.
(3) Form circular shape.
(4) Make hooks for side seam.
(5) Close hooks into side seam.
(6) Flange end of the body for seam.
(7) Make end.
(8) Seam end on to the body.

To these basic operations must be added:

(9) Produce component(s) for top closure.
(10) Seam on top closure if required.

If the container has to carry liquids some seam filling operations must be added such as:

(11) Solder side seams.

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SHEET METAL DATA SHEET

Manufacture of Tin Boxes—3 (Cont.)

(12) Solder top and bottom seams, or

(12a) Curl and line ends with solution.

(13) Some testing of whole or part of output.

PLANT USED

The plant used depends on (a) the outputs required (b) the size variability of the output (c) capital available.

Very roughly, for the purposes of this data sheet, the outputs may be graded into small (15 to 30 per minute) medium (100 to 200 per minute) and large (300 to 450 per minute).

The plant for the large outputs is usually kept on one diameter. Where fairly constant size changes are required then either small output or lower range of medium outputs (about 100 per minute) plant is used. Capital often determines which.

Plant for Small Output Line

Cutting	Guillotine or gang slitter
Notching	Special-purpose machine—hand, foot or power
Trim shape	Bending rolls
Make side seam	Automatic side seamer
Flange bodies	Special-purpose flanger—simple type
Make end	Power press and tool (C-type press)
Seam in end	Semi-automatic seamer

Components Top Closure Produced in Power Presses

Seam on top	Semi-auto seamer
Seam filling mostly by	hand operations
Testing	Simple form tester

Plant for Medium Outputs

Cutting	Gang slitter
Notching, forming	Automatic bodymaker
Production side seam	
Flange bodies	Special-purpose flanger—chute-fed type
Make end	Power press and tool (probably auto strip-feed press)
Curl	End curler
Line end	Lining machine
Seam in end	Semi-auto seamer with special feeds

Components Top Closure Produced in Power Presses

Ends curled and lined	Special machines
Side-seam filling	Hand or solder horse extension to bodymaker
Top seamed on	Semi-auto seamer with special feeds
Seams	Machine soldered
Testing	Vacuum testers

Plant for Large Outputs

Cutting	Duplex gang slitters
Flexing, notching Forming Production side Seam, solder side Seam	Automatic body-former with solder horse extension
Flange	High-speed pressure flange
Make ends	Auto-strip-feed press
	Double dies on small sizes
	Strip notched in scroll shear previously
Curl ends	End curler
Line ends	Automatic lining machine
Seam on ends	Automatic double seaming machine
Test	Automatic wheel testing machine

The top closure here is usually an end as the base, and produced as above for the ends. The filling is done at the packer's works and the top seamed on there in automatic or semi-automatic double seamers.

On all three types connexion conveyors between the machines are desirable. In the case of the plant for the large outputs these must be extensive and form reservoirs of components between operations in case of any single machine breakdown.

The plant for the small output relies to a greater extent on the skill of the operators. That for the large outputs needs high standard of technical backing.

SHEET METAL DATA SHEET 15

Manufacture of Tin Boxes—3 (Cont.)

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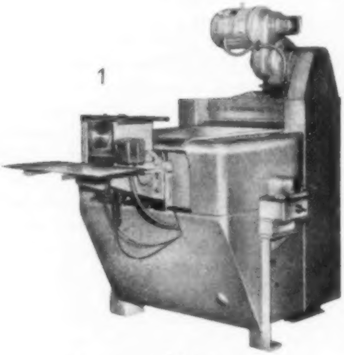

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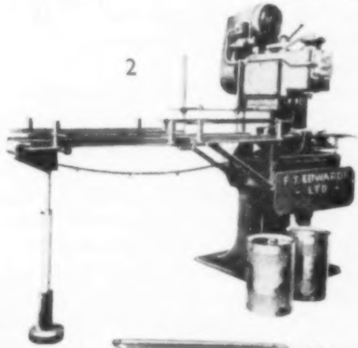

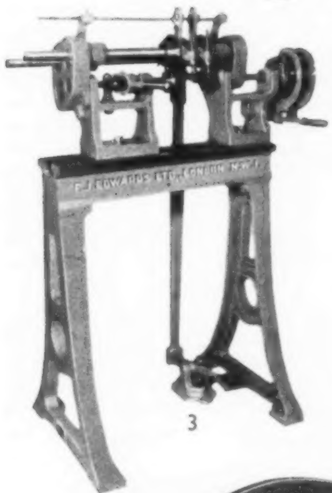

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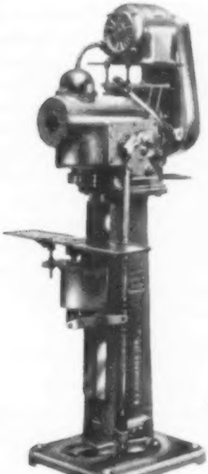
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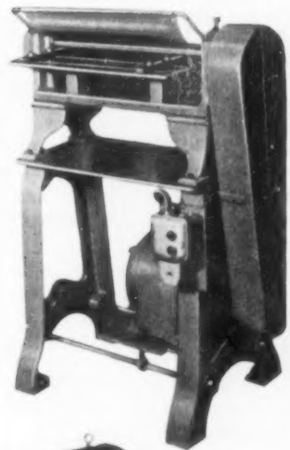

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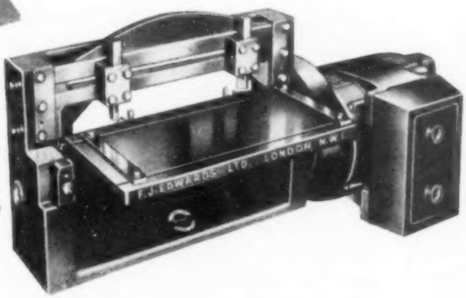
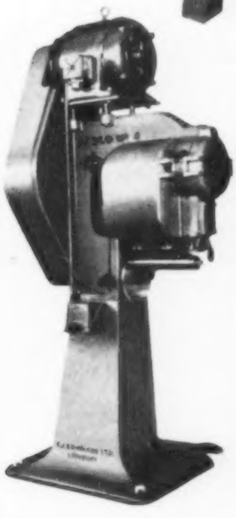



7

1.—Automatic body maker
2.—Automatic seamer with track feed
3.—Simpler type rotary flanger
4.—Semi-automatic round double seaming machine
5.—Power forming rolls
6.—Double-ended power notcher
7.—Semi-automatic side seaming machine

Flow-line Production on Batch Work

(*Continued from page* 210)

punched across the sheet, approximately one-sixth of the length in from each edge. This ensures that the holes line up when the runners are assembled to the body.

A second operator on the same press brake cuts two square corner notches (Fig. 3) on one side of the sheet after the holes have been punched.

Then, without returning the main body to the floor, it is passed over the centre table to the second press brake. Five more holes are punched along the length of the sheet on one side, and the sheet passed to a second operator on the same machine who cuts two corner and two vee notches along the other side.

Before a tool-change is carried out, however, for further press-brake operations, five mating holes in the inner and outer members of the drawer front (Fig. 4) are punched in the respective blanks. These inner and outer members of the drawer front are then transferred to the second production line for punching the handhole, folding, notching and so on, thus maintaining an even flow of work to the assembly shop. The back member of the drawer is formed entirely on the second line.

Assembly on the Press Brake

The second sequence of operations to be carried out on the main body is tooled up once all mating holes have been punched. On one press brake two tools are set up, one to fold along the top and bottom edges and the second to crush the fold.

The second press brake is used for an assembly operation before the body is finally folded. It is tooled up to rivet the runners to the main body (Fig. 5). Rivets are positioned in one runner at a time and riveted over at one stroke of the press.

A second tool in the same machine (Fig. 6) makes the fold.

The body then moves to the assembly shop where first the back and then the inner member of the drawer-front are spot-welded in position by the 75-kVA Metro-Vick spot-welder (Fig. 7). The outer member hooks over the top of the inner member and is secured in place by five No. 8 PK self-tapping screws (Fig 8), on the underside. Finally, stops and runner-rollers are fitted completing a dust and insect-proof drawer when enclosed within its cabinet.

Not all machines in the line were used on this occasion. Spot welding was more conveniently done in the assembly shop and no drilling was required at all, but this does show how Randalls have minimized handling by applying flow-line techniques to batch work.

Production Procedures at John Thompsons Motor Pressings Ltd.

(*Continued from page* 170)

In addition, as mentioned previously, arc welding is resorted to to weld in position where it is impossible to spotweld or to add strength on corners etc.

It should be noted that those components mentioned as being part of the various sub-assemblies and not referred to in the main assembly sequence are attached mainly by spot-welding or projection welding and sometimes by arc welding as required. This applies to tapping plates, doubling plates, weld nuts, brackets, etc.

The object of listing in detail the breakdown of operations used in the frame assembly is to illustrate that by careful planning carried out jointly by the equipment designers and the body builders, the cost and complexity of the installation can be reduced to a minimum.

The use of special-purpose multi-welding installations can only be justified where the output required is of sufficient size to show a reasonable economy over a period of 3 to 5 years. For lower production it is still necessary to rely on standard equipments but these can be supplemented by the use of special toolings and adaptions such as have been used in the Sprite layout to reduce fatigue and operation times.

Further savings are effected by careful planning of the fixture design so that by combining on a single fixture a series of successive operations to progressively build up a main sub-assembly the production force is reduced to a minimum and the time of each operator fully utilized. Similarly the cost of welding equipment is reduced as a suitably designed gun or pair of guns can meet all welding requirements planned for each fixture.

Finally, in the planning stages, careful attention was paid to obtaining, as nearly as possible, a common cycle time for each series of operations and thus providing a uniform flow, free from bottlenecks or waiting time.

The next instalment in this series will describe the production of the frame for the current series of Rolls-Royce and Bentley motor cars.

INSTITUTE OF SHEET METAL ENGINEERING

BRANCH ACTIVITIES

A NUMBER of very well attended meetings has been held by the Branches and Sections of the Institute in recent weeks. On February 8 about 120 members of the Midland Branch heard a lecture by Mr. E. Hamilton (Wilkins and Mitchell Ltd.) on "The Development and Building of Large Power Presses." The final scheduled meeting of the Branch is the Annual General Meeting and Film Show to be held on March 8, but in view of the outstanding reception given to the exploratory meeting held by the Branch recently in Coventry, it has been decided to stage a further meeting in that City before the end of the present Session. Particulars of the date and location of this meeting will be announced shortly. The Wolverhampton Section of the Branch had a change of programme at its meeting on January 25, and instead of the advertised subject members were given a paper by Mr. J. Galway (C.V.A. Jigs and Tools Ltd.) on "Tooling Techniques for High-Speed Presswork." This paper aroused much interest and was keenly discussed by the capacity attendance. On February 22 a party of members were privileged to visit the Bilston Works of Joseph Sankey and Sons Ltd., where a most interesting afternoon was spent. The demand for participation in this visit greatly exceeded the number that could be accommodated and through the great courtesy of the directors of the company, arrangements were made for a further party to visit the works on the following day. The Section's programme for the Session concludes with the Annual General Meeting and Film Show to be held on March 29.

The last meeting of the North-West Branch held on February 8, was taken up with a Forum on "Press Tools for Small Batch Production" at which five speakers contributed briefly on a specialized aspect of the subject and then went on to answer and discuss the many questions submitted to them by the hundred or so members and visitors present. Membership of the Branch continues to grow, particularly in the Liverpool area, where further meetings during the next Session are contemplated following the successful experimental meeting held in that area recently.

In Bristol the South-West Branch provided its members with an opportunity to discuss modern trends in the applications of aluminium on January 31 when two papers on the subject were presented. One was by Mr. M. Bridgewater (Alcan Industries Ltd.) and the other by Mr. O. R. Benton (Bristol Aircraft Ltd.) At the next meeting to be held on March 14 the subject to be discussed will be the latest developments in argon-shrouded welding and in flame cutting.

All Branch Committees have under active consideration at the present time the technical programmes for their Branches for the 1961-62 Session, and Branch Secretaries will be interested to receive offers of papers for presentation at Branch Meetings, or suggestions from members of subjects on which contributions or discussions would be welcomed.

CORROSION SCIENCE SOCIETY

THE second Symposium of the Corrosion Science Society will be held on April 6-7, 1961, at the Battersea College of Technology, and will follow the same general lines as the meeting held in April, 1960.

The proceedings will be kept as informal as possible, so as to encourage discussion and debate. No discussion will be published. The talks and papers to be given will be concerned with very recent work and with research still in progress. The provisional programme consists of four technical sessions and fourteen papers.

Membership of the Symposium is open to any professionally qualified scientist or technologist working in the general field of the corrosion and protection of metals. Application forms for membership of the Symposium, which must be returned duly completed before March 29, may be obtained from Dr. T. P. Hoar, Department of Metallurgy, Pembroke Street, Cambridge, and Dr. L. L. Schrier, Battersea College of Technology, Battersea Park Road, London, S.W.11.

PRACTICAL PLATERS' NIGHT

THE Committee of the London Branch of the Institute of Metal Finishing have arranged a further "Practical Platers' Night" (the fifth to be held) to take place at the Constitutional Club, Northumberland Avenue, London, W.C.2, on Friday, March 10, 1961. The bar will be open at 6 p.m. and the meeting starts at 6.30 p.m. There will be a buffet at 8 p.m. Tickets, price 15s. (exclusive of alcoholic levelling agent) may be obtained from Mr. J. M. Shepherd, 18 Bentham Avenue, Sheerwater, Woking, Surrey.

Résumés des Principaux Articles

refoulage à froid de l'acier. Il traite du choix des matériaux d'outillage à la lumière des indications déjà publiées, provenant de sources mondiales; il renseigne sur les défauts qui peuvent se rencontrer dans les aciers à outils; il fait certaines recommandations au sujet de la pratique du traitement par la chaleur, etc., et il aboutit à la conclusion que, pour le poinçon et la matrice, c'est l'acier rapid au molybdénum qui conviendrait au poinçon, alors que le carbure métallique conviendrait à la matrice. Enfin, l'auteur appui sur la nécéssité d'une co-operation serrée avec le fournisseur de l'acier, ainsi que dans l'execution de ses recommandations en ce qui concerne le traitement de l'acier.

Production en Debit Continu dans la Fabrication par Lots page 208

Cet article décrit les méthodes de production en débit continu telles qu'elles sont appliquées à la fabrication par lots dans l'usine de Paddington de la Société H. Randall & Son Ltd. où la disposition des machines a été étudiée afin de réduire au minimum le nombre de manipulations des ébauches. Les machines sont disposées sur deux lignes pour conserver une production équilibrée et assurer leur utilisation maximum. Elles comprennent des presses aussi bien que des machines à souder par points. Cet article décrit également la suite des opérations dans l'exécution de commandes directes et en sous-traitant, et fait mention du principe de la construction de nouvelles machines à partir de pièces provenant d'ensembles superflus.

Introduction à la Théorie et a la Pratique du Laminage de Tôles Planes—7 page 211

Par C. W. Starling, B.Eng., A.M.I.Mech.E. (décédé)

Ce chapitre du manuel de cet auteur traite de la mesure de la charge et du couple au cours du laminage. Les systèmes de mesure de la charge sont suivis de descriptions détaillées des différents types d'instruments mécaniques, hydrauliques et éléctriques de mesure de charge. De même, après avoir examiné les systèmes de mesure du couple, il donne des détails sur les systèmes mécaniques et éléctriques qui peuvent servir à mesurer le couple.

Zusammenfassungen der Hauptartikel

von Stahl" gehalten. Er behandelt die Auswahl von Werkzeugmaterialien im Lichte von bereits veröffentlichten Daten aus aller Welt, gibt Einzelheiten über in Werkzeugstählen gefundene Fehler und macht Empfehlungen bezüglich Wärmebehandlung usw. Es wird gefolgert, daß als Material für den Stempel Molybdän-Schnellstahl und für die Matrize Molybdänkarbid besonders geeignet ist. Abschließend betont der Verfasser die Notwendigkeit enger Zusammenarbeit mit dem Stahllieferanten und der Befolgung seiner Empfehlungen hinsichtlich der Behandlung des Stahls.

Fliessfertigung im Kleinserienbau .. Seite 208

Der Artikel beschreibt die Anwendung von Fließfertigungsverfahren bei der Herstellung kleiner Serien im Werk Paddington der James H. Randall & Son Ltd., wo die Anordnung der Maschinen so getroffen ist, daß ein Werkstück möglichst selten aufgenommen zu werden braucht. Zur Erzielung ausgeglichener Fertigung und bester Maschinenausnutzung sind die Maschinen in zwei Linien angeordnet, die sowohl Pressen als auch Punktschweißmaschinen enthalten. Der Arbeitsablauf für Original- und Unterauftragsarbeiten wird beschrieben und die Herstellung neuer Werkzeuge aus Altmaterial erwähnt.

Einführung in die Theorie und Praxis des Blechwalzens —7 .. .. Seite 211

Von C. W. Starling†, B.Eng., A.M.I.Mech.E.

Dieses Kapitel im Lehrbuch des verstorbenen Verfassers befaßt sich mit der Messung von Belastung und Drehmoment beim Walzen. Auf die Methoden zur Messung der Belastung folgen Einzelheiten über verschiedene mechanische, hydraulische und elektrische Belastungsmesser. Ebenso werden nach Beschreibung von Drehmoment-Meßmethoden mechanische und elektrische Systeme im einzelnen behandelt, die zur Drehmomentmessung gebraucht werden können.

Résumenes de los Artículos Principales

I.I.C.M. Estudia la elección de materias primas para herramientas teniendo en cuenta todos los datos ya publicados de fuentes de todo el mundo, ofrece detalles de los defectos que pueden hallarse en aceros para herramientas, comprende recomendaciones para tratamientos térmicos, etc. y llega a la conclusión de que, para el sistema de puzón y troquel, el acero rápido al molibdeno resultaria un material adecuado para el puzón y el carburo para el troquel. Finalmente, el autor hace hincapié sobre la necesidad de cultivar una estrecha cooperación con el proveedor del acero y de seguir los consejos del proveedor en lo que se refiere a todo tratamiento dado al acero.

Cadena de Produccion Fluida para la Fabricacion por Lotes pagina 208

Este articulo describe métodos de "cadena fluida" aplicados a la producción por lotes en la fábrica de Paddington de la James H. Randall & Son Ltd., en la que la disposición de las máquinas se ha planteado de forma que se pudiese reducir a un mínimo el número de veces que se han de alzar una pieza en blanco. Las máquinas están dispuestas en dos líneas para mantener la producción equilibrada y un alto nivel de utilización de las máquinas que comprenden tanto prensas como soldadoras por puntos. También se describe el ciclo de operaciones para trabajos originales y subcontratados y se hace referencia al criterio de construir herramientas nuevas a base de conjuntos que han dejado de ser útiles.

Presentacion de la Teoria y la Practica del Laminado Plano —7.. .. .. pagina 211

Por C. W. Starling, B.Eng., A.M.I.Mech.E.

Este capitulo del libro de texto del autor trata de la medición de la carga y la torsión de laminación. Los métodos para medir la carga van seguidos por detalles de los diversos cargómetros mecánicos, hidráulicos y eléctricos. Igualmente, después de estudiar los sistemas para medir la torsión, se dan datos sobre los sistemas mecánicos e hidráulicos que pueden emplearse para la medición de la torsión.

SHEET METAL NEWS

FEATURING EVENTS AND PERSONALITIES IN THE INDUSTRY

INSTITUTE OF METALS

Spring Meeting, London

THE Spring Meeting of the Institute of Metals will be held in London, at Church House, Great Smith Street, S.W.1, in the Hoare Memorial Hall, from March 21 to 23 inclusive. The installation of the new president, Professor H. O'Neill, M.Met., D.Sc., F.I.M., will take place on the morning of Tuesday, March 21, after which he will deliver his presidential address. The May Lecture this year will be given by Professor M. Polanyi, D.Sc., F.R.S., on the evening of March 21 at the Lecture Theatre of The Royal Institution, Albemarle Street, London, W.1. Professor Polanyi has chosen for his theme "Science: Academic and Industrial." Visitors will be welcome at the presidential address, the May Lecture and any of the discussions.

Two social functions will be held during the Meeting, *viz:* a conversatzione and exhibition on the evening of March 22 at 17, Belgrave Square, London, S.W.1, and the Institute's annual dinner and dance, which will be held at Grosvenor House, Park Lane, London, W.1, on the evening of March 23.

Readers may be interested in the fact that on Thursday, March 23, technical sessions will be devoted to a discussion on "Extrusion," two of the papers to be considered being "The Cold Extrusion of Metals using Lubrication at Slow Speeds" and "Further Experiments in the Cold Extrusion of Metals using Lubrication at Slow Speeds," the joint authors of both these papers being R. S. Wilcox and P. W. Whitton.

SHEET METAL FIRM OCCUPY NEW PREMISES

THE HYCLAMET CO. LTD., whose present works are at Gatwick House, Povey Cross Road, Horley, Surrey, are shortly occupying new premises at Red Kiln Way, Kings Road, Horsham, Sussex. This move has been occasioned by increasing demand of new and old customers for more capacity, and as the company are specialists in prototype and research work, a site was chosen so that close contact could be maintained with customers.

The company produce components for the electronics and allied industries using in the main universal tooling in order to keep manufacturing costs down. Shearing capacity up to 8 ft. × ⅛ in. is available and a Bronx press brake with a capacity of 10 ft. × 14 s.w.g. has also been installed. The new factory now being erected will be further expanded in 1963.

British Drum Making Machinery For Germany

A new model of their double-ended seamer for large steel drums, also a bead expander, by Moon Brothers Ltd. of Birkenhead, is shown loaded on a cross-channel transporter on which it will travel to its destination in Germany.

Moon Brothers Ltd. are manufacturers of specialized drum-making machinery and equipment which is used in all parts of the world.

NEW CONVEYOR SYSTEM INCREASES WASHING-MACHINE PRODUCTION

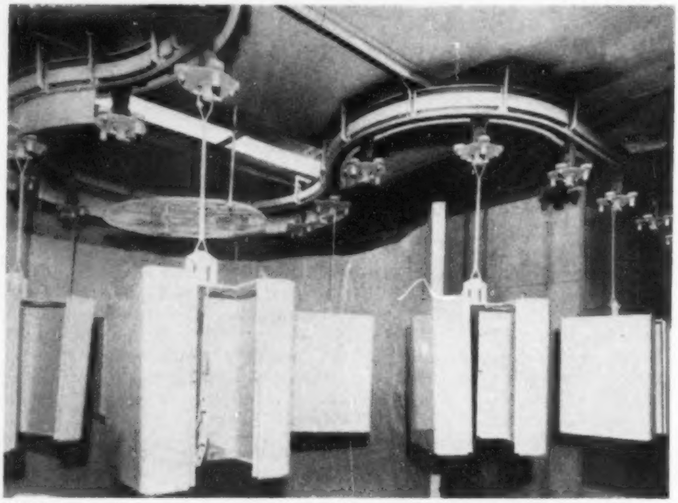
WILKINS AND MITCHELL LTD. of Darlaston, Staffs., one of Britain's leading manufacturers of washing machines, who have recently produced their one-millionth model, have installed a conveyor system, produced by Fisher and Ludlow Ltd., Tipton, Staffs., in two sections of a new plant in which production is being integrated and output increased to meet the growing demand for products. Overhead conveyors are used for processing and painting washing-machine components and belt and roller conveyors are combined to handle parts in a well-planned assembly shop.

The components are pre-formed and welded in a "black-stock" shop and hung on hook-type carriers suspended on two "Flow-link" tracks about 600 ft. long which travel at a speed of six ft. per min. to an adjoining paint shop where they first pass through one of two pre-treatment tunnels, consisting of six stations, including intermediate rinses, where the components are automatically degreased, chemically cleaned, given a rust-inhibiting phosphate coating and dried. The two tracks then pass through a primer-painting booth where the components are totally immersed in vats of primer paint and after passing through a drip and flash-off section, enter infra-red stoving ovens and are finally off-loaded for inspection before final painting; the carriers are returned to the "black-stock" shop.

The final painting process is served by another pair of "Flow-link" conveyors, 300 and 350 ft. long. Components on these conveyors first pass spray gun stations where they receive preliminary attention and then into one of two Ransburg electrostatic painting booths in which components are sprayed by a reciprocating disc charged at 100,000 volts. The components then emerge through a flash-off section and after passing through one of two more infra-red drying ovens, drop to a station where the components are off-loaded for inspection.

The inspection area includes a loading station for the main service conveyor, 1,200 ft. long, moving at 18 ft. per min. on which painted parts after inspection are carried through a 250-ft. long underground tunnel into the final assembly shop, 290 ft. by 80 ft.

The assembly shop is divided into two sections for the two types of machine produced; down the centre of each section there are two conveyors, one 120 ft. and the other 90 ft., with a 2-ft. wide belt, moving at variable speeds, on which machines are assembled. Other conveyors from the perimeter of the shop deliver parts such as spinners and drive units to the assemblers. Complete machines pass from assembly conveyors on to sections of roller track into a central, sound-insulated inspection room, where with the aid of revolving tables and hydraulic lifts, they are subjected to stringent tests, both visual and manual, including electrical high voltage flash-testing and motor noise-level testing. Machines that pass these tests travel on a slatted conveyor to the nearby packing and despatch department.



Washing machine components on a loop of Flow-link track in an electrostatic painting room at Wilkins and Mitchell Ltd., Darlaston, Staffs.

NEW AUTOMATED SLAB MILL IS INSTALLED IN U.S.

A NEW automated slabbing mill, built for Inland Steel Co., is the first of its kind in the United States. The control system for the mill was designed and built by U.S. General Electric. The mill performs a whole rolling operation, which includes as many as 23 "passes" of the ingot back and forth through the mill rolls. The operations are guided by punched cards in a card reader.

A TV set in the control room enables the controller to see the ingot approaching from the other side of the mill. The screen, marked with a measuring grid, spots an oversize ingot immediately. The automated mill, which has been operating at an annual capacity of 1,600,000 tons, can roll a 20-ton slab every 90 seconds.

COURSES IN WORK STUDY

THE School of Works Study Ltd., 11, Burlington Street, London, W.1, which was founded in 1951, has added two new courses to its programme to be run periodically throughout the year. Course "F" is a ten-weeks course, designed to prepare candidates to take their place in an existing work-study team and places heavy emphasis on work measurement, including advanced techniques. Three weeks of the course are spent in host factories under supervision; the fee is 150 guineas. Course "G" trains existing work study personnel who are destined for promotion as section leaders. Tests, revision and advanced techniques are taught; the course lasts two weeks and costs 50 guineas. The first of course "F" commenced February 6 and the first of course "G" starts March 20.

PROTECTION OF CHROME AND OTHER METALS

THE Goodyear Tyre and Rubber Co. (Akron, Ohio) have produced a tough plastic coating in a resin or pellet-like form—" Vitel," which can be made into clear or tinted liquid solutions that form hard, glossy protective films adhering well to chrome, aluminium, steel and other metals and will not peel off. The coating prevents rust and tarnishing and has excellent scratch and abrasion resistance; tests show that hubcaps coated with Vitel still look new after more than a year of actual service over all types of roads and in all types of weather; washing with clear water restores the original lustre. The coating can be applied by brushing or dipping or can be adapted to handy spray applicators.

Photo' Resist for Etched Copper Circuits

THE Meaker Co., Nutley 10, New Jersey, U.S.A., a subsidiary of the Sel-Rex Corporation, have produced a new photo resist, " Resist-Etch," which is said to positively block off unwanted electroplate and to permit accurately defined electroplated patterns in printed circuits calling for lines 0.005 in. wide spaced 0.005 in. apart, even when used by relatively unskilled labour. Other features are said to be freedom from pinholes, not affected by all plating cycles, yet easily removed by its companion product Resistrip, will not contaminate base or precious metal plating solutions and freedom from toxicity.

CONTINUOUS LEVELLER AND CUT UP LINE

SHOWN in the accompanying photograph is the new Ungerer seventeen-roll leveller and flying shear cut-up line recently installed at the main factory of the Ayrshire Dockyard Co. Ltd., Irvine. Two adjustable expanding drum-type decoilers are used, one each for steel and aluminium. This arrangement takes care of the normal range of core diameter variation as received from the mills. The two decoilers are situated a suitable distance from the entry side of the leveller to accommodate already cut flat sheets for an additional levelling pass if required.

Sheets are cut to length by a reciprocating high-speed guillotine electrically controlled by a trigger mechanism engaged by the leading edge of the sheet. The guillotine is accelerated horizontally to a speed synchronized with the rate of feed of the sheet, the cut made and the guillotine returned to the stand-by position, all in one operation. Cutting to length is accomplished without interruption to the flow of sheet and the elimination of the more usual hump table results in a more compact layout and an improved flatness of cut sheet.

Installation of this new cut up line has enabled Ayrshire Dockyard to give a much improved service to their customers by eliminating the delivery period taken by the continuous sheet mills for special sheet sizes.

The line is designed to produce flat sheets from 3 ft. 6 in. up to 16 ft. in length and up to 50 in. wide in 26 gauge to 12 gauge mild steel, and 20 gauge to 10 gauge aluminium.

UNUSUAL COIL ANNEALING FURNACES

A BATTERY of four unusual coil annealing furnaces which use an oil-fired radiant-tube heating system, has been ordered by James Booth Aluminium Ltd. from AEI-Birlec Ltd. (Tyburn Road, Birmingham, 24). The equipment, costing well over £100,000, incorporates a number of features which are expected to have a significant influence on European aluminium mill practice. It will be installed in their Kitts Green works, Birmingham, as part of James Booth's £6 million re-equipment and expansion programme which is scheduled for completion this year.

Each of the four furnaces has a usable chamber 6 ft. high, and measuring 20 ft. by 14 ft., which will take a 32-ton charge of coiled aluminium strip. Heating is by batteries of temperature-controlled, oil-fired, radiant heating tubes, over which the furnace atmosphere is circulated at exceptionally high speeds by eight powerful motor-driven fans. The charge is also cooled in the furnace, at a controlled rate, before being discharged. An electrically-driven charging machine loads and unloads the four furnace chambers.

ULTRASONIC EQUIPMENT FOR GOLD PLATING

ULTRASONIC generator and transducer equipment is used by IDM Electronics Ltd. in the production of gold-plated commutators and slip-rings by a process carried out under licence from the Electro Tech Corporation in the U.S.A. and consists essentially of encapsulating lead wires in a cylinder of plastic which is cured and then machine grooved. One wire is locally exposed in each groove, all of which are then filled by a gold-plating process and machined and polished to a surface finish of four micro-inches. Slip-rings and commutators produced by this process are claimed to have considerable advantages over those produced by other techniques, having great mechanical strength, excellent wearing properties and are little affected by wide changes in temperature and humidity. The plating operation is very complex and it is necessary to exercise great care to ensure homogeneity especially when gold thicknesses above 0.015 inches are used; this is assisted by the use of a Dawe type 1152 2/0.5 kW generator powering four 1,160/B36 immersible transducers in the plating tanks.

Books for Your Library

Tin and its Alloys. E. C. Ellwood, W. E. Hoare and W. R. Lewis, joint authors, E. S. Hedges, editor. London: 25 February, 1960. Edward Arnold Ltd., 41, Maddox Street, London, W.1. 432 pp., illustrated, 6 gns.

THIS exceedingly attractive and well produced book is at once welcomed as a modern authoritative work on the properties and applications of tin and its alloys. All the authors responsible for the extensive subject coverage have, at some time, worked together on various research and development problems at the Tin Research Institute, Greenford. This close personal association between the authors has undoubtedly paid dividends and culminated in a far better co-ordination of efforts than is usually the case when a collection of specialists are invited to contribute individual chapters in the treatment of some omnibus subject.

A short description of the extent and scope of the tin industry is given in an introductory chapter. No attempt is made to deal with the mining, smelting and refining of tin but this omission is undoubtedly wise as an adequate treatment of this topic would have further increased the already high price of the book while only catering for a minority interest among its readers. This chapter also briefly surveys the uses of tin and its alloys and sets the stage for the contents of the ensuing ten chapters. In this connexion it might be of interest to warn chemists, rather than metallurgists, that the book does not purport to deal with either chemical analysis or the chemical compounds of tin. The common usage of stannous sulphate and chloride and sodium and potassium stannates in the electrodeposition of tin are, of course, obvious exceptions but anyone interested in the use and development of tin compounds in plastics, paints, medicines and fungicides will be disappointed.

The text proper commences with a survey of the domestic and artistic uses of pure and hardened tin (pewter) in both cast and wrought forms. The versatility of tin for these applications is made most apparent by a number of well-chosen photographs which illustrate various fabrication techniques as well as some superb examples of craftsmanship—both old and contemporary.

The various physical and mechanical properties of tin and tin alloys (other than bronzes, type metals, bearing alloys and solders which are dealt with in other chapters) are discussed in Chapter III. For example, the legendary $\beta \rightarrow \alpha$ allotropic transformation and the strong tendency for tin to form a variety of intermetallic compounds with other metals are both discussed at length. The chemical behaviour of tin when in contact with gases, aqueous solutions, acids, alkalis and a miscellaneous selection of organic and inorganic substances is dealt with in Chapter V. Not surprisingly, the peculiar electrochemistry of the tin-iron couple which is so fundamental to the tinplate and canning industries is explained here.

One chapter deals exclusively with electrodeposition and includes a comprehensive survey of the numerous research publications and patents devoted to the deposition of tin, including the co-deposition of binary and ternary tin alloys, as well as giving a great deal of practical information about the various batch plating processes. Two chapters devoted to hot tinning and tinplate manufacture follow in natural sequence. The first of these chapters is concerned with the theory and practice of the batch tinning process as applied to steel, copper, brass, bronze, aluminium and cast iron. The fully mechanized processes for the hot-dip tinning and electrolytic coating of steel sheets or strip are discussed in the second chapter. In particular, this chapter gives a useful comparison of the three main electrolytic coating processes using stannous sulphate electrolytes (Ferrostan lines), stannous chloride electrolytes (Halogen lines) and alkaline stannate electrolytes (Alkaline lines).

The remaining four chapters deal specifically with the remaining major uses of tin in bearing alloys (VIII), die casting alloys—including fusible alloys, type metals and amalgams (IX), solders (X) and bronzes (XI).

Few books can have been produced with such care and attention to detail from both theoretical and practical viewpoints. The style and presentation is delightful and although the price is rather high, this is undoubtedly a book which any person concerned with the metallurgy of tin will be glad to possess.

H. LLOYD.

A Practical Manual of Industrial Finishes on Wood, Metal and Other Surfaces, by B. M. Letsky, pp. 251 + xii, 40 figs. London: Chapman and Hall (1960). Price 35s.

MR. LETSKY has been a prolific contributor to the literature on organic finishes over the years, and in the present volume he has distilled, as it were, the essence of his wide experience for the benefit of those engaged in the industry. This book is, however, no mere formulary, and the author strikes a nice balance between practical instructions and the theoretical reasons on which they are based.

The book is almost equally divided between finishes for wood and for metal, and is very much up-to-date so far as processes and materials are concerned. The author writes clearly and concisely; in fact he has had to do so in order to cover the wide range of subjects he has included within a limited space. In a little over one hundred pages, so far as metals are concerned, for instance, he deals with formulations, application methods, plant design and layout, and testing procedures. There is also a chapter on wrinkle, hammer and other special finishes and on organosols.

The book is well printed and produced and will be found to be a most valuable publication to have at hand—especially by the man in a hurry.

H. SILMAN.

Electropolishing, Anodising and Electrolytic Pickling of Metals, by N. P. Fedot'eo and S. Ya. Grilikhes, translated by A. Behr. Robert Draper Ltd. 285 pp., illustrated. Price 58s.

FEW metal-finishing technologists have a working knowledge of Russian and acquaintance with Russian technical literature has been confined to abstracts of Russian originals which until recently were sadly inadequate. It has become increasingly evident that in this field, as in others, there are useful ideas to be gained from closer acquaintance with their contributions to technology. The publishers are to be congratulated on being the first to embark on publication of a full-scale translation of a Russian book on metal finishing.

To our ears the title sounds clumsy, but at least it states accurately the contents of the book. The unity of the text depends on the fact that the processes described are all electrolytic, and most of them anodic. In

(*Continued in page* 229)

Books for Your Library

(*Continued from page* 228)

fact the first two chapters fulfil the function of providing the theoretical framework underlying the processes described and in respect of anodic processes attempt to offer a theoretical model for them. This model is largely a summary of work carried out by Grilikhes for his Candidate's Dissertation. One suspects that the book originated as a literature review prior to the commencement of this research.

It is difficult to judge whether this book gives a fair indication of Russian practice. If one opinion is correct, there are definite indications that in some respects the Russians are making more use of electropolishing of steel, particularly carbon steels, than is the case in this country. Certainly, one of the particular attractions of the book is the amount of practical detail it contains. Having no reason to maintain, for commercial reasons, secrecy on composition and processing "know-how", there is no difficulty in the U.S.S.R. about publishing this information. One cannot fail to note that there seems to be considerable effort devoted to investigating the "know-how" of such processes.

Although much of the information on the Battelle phosphoric-sulphuric-chromic electrolyte will not be new to those acquainted with the art, this book provides this information conveniently under one cover and well set out.

Of course the book also has its limitations. The processes described are mainly ones filched from the capitalist West and placed in the service of communism without acknowledgement to their originators. There are few references to relevant work outside Russia (particularly American), although it is probable that a Russian would similarly criticize any British book. Some of the views expressed on mechanism of processes could well be subject to a little comradely criticism by our academic colleagues.

The sections dealing with electropolishing of copper, nickel, aluminium, zinc and other metals gives briefer but adequate coverage of the important processes for these metals. The sections dealing with practical aspects and effects on properties are particularly useful. About a quarter of the book is concerned with aluminium. The review of the basic mechanism of anodizing lacks acquaintance with more recent significant contributions from outside of Russia. The chapter on Industrial Anodizing is nevertheless quite a sound summary of relevant practice.

There are some minor mistranslations and errors, although these are very few for a work of such complexity. Of course the price is sufficiently high to discourage many technologists acquiring a copy out of their own pockets. They should not have undue difficulty in persuading their company that this is a book which should undoubtedly be in the library.

A. W. BRACE.

Industrial Finishing Year Book, 1960. The Arrow Press Ltd., 1 Stamford Street, London, S.E.1. 296 pp. Free to subscribers to "Industrial Finishing" or 15s. post paid.

THIS book covers as far as possible in a single volume the whole field of industrial finishing and contains a wealth of information, much of it in tabular form, grouped for convenience and easy reference under various headings. A short opening section on workshop practice contains brief facts on materials handling, safety equipment, flooring, air conditioning and protective clothing. Besides comprehensive tables listing cleaning solutions, the physical characteristics of electrodeposited coats, the properties and uses of synthetic coatings, polishing wheel grit sizes, metal colouring treatments and the physical constants of oils, there are tables referring to the faulty deposits from plating baths and how to correct them and suggested metal etching procedures. There is also much to be read on paints, pigments and corrosion protectives.

Research on the Rolling of Strip—a symposium of selected papers 1948-1958. The British Iron and Steel Research Association, 11 Park Street, London, W.1. 216 pp. Light card covers. Free to BISRA members. £1 1s. to others.

THIS is a collection of selected papers on the subject of rolling strip produced during the period 1948–1958 which was particularly productive of original papers on the mechanics of strip rolling published in various engineering and metallurgical literature. The presentation of these papers in one volume is the result of considerable research and should be of interest and material help to all concerned with the subject, particularly rolling mill engineers and designers. The gradual development of practical and reliable methods of rolling-mill calculations from basic theory is well illustrated and the subject should be of considerable importance at a time when there are rapid developments in rolling mill design and control, stimulated by the increasing demand for high quality steel strip by the consuming industries. A total of 17 papers are presented, complete with graphs and tables; there is a foreword by Professor Hugh Ford, D.Sc.(Eng.), Ph.D., and an introduction by Mr. W. C. F. Hessenberg, M.A., F.I.M., deputy director of BISRA.

Tinplate Testing—Chemical and Physical Methods, by W. E. Hoare, D.Sc., F.I.M. and S. C. Britton, M.A., F.R.I.C., F.I.M. 1960. Tin Research Institute, Fraser Road, Perivale, Middlesex. 55 pp. Free on official application.

THIS handbook is in two parts, the first forming a general account of the purpose, scope and applications of quality and performance tests, particularly those that relate to corrosion resistance, lacquerability and solderability, the second part being a series of appendices giving precise details of testing procedures. The booklet may be considered as complementary to the Institute's "Tinplate Handbook" which provides general information on tinplate and detailed information of the qualities commercially available. The booklet is well illustrated.

Sell's British Aviation—1960 Edition. Business Dictionaries Ltd., St. Dunstan's House, 133–137 Fetter Lane, Fleet Street, London, E.C.4. 221 pp.

THE 1960 edition of this attains the thirteenth year of publication and provides reliable information concerning the organization and activities of the British Aircraft Industry for the convenience of aviation buyers and officials among whom it circulates. The first section contains the names of all the principal firms in British aviation in alphabetical order, with trades, postal and cable addresses and other details. The second section is a classified trade guide to constructors of aircraft and aero engines, manufacturers and suppliers of parts, accessories and materials, aircraft dealers, airlines and independent air transport companies and other aviation services. This is followed by a trade names and marks section giving short particulars of British civil aircraft which are in various stages of production.

Forthcoming Events . . .

March 2

Institute of Metals (Birmingham Local Section). "Rating Sheet Metal Formability by Press Performance," by D. H. Lloyd, F.R.I.C., F.I.M., at the College of Technology, Gosta Green, Birmingham. 6.30 p.m.

March 7

Institute of Metals (South Wales Local Section). "Fracture of Metals," by K. E. Puttick, Ph.D., in the Metallurgy Dept., University College, Singleton Park, Swansea. 6.30 p.m.

Institute of Metals (Oxford Local Section). "Novel Methods of Forming Metals," by J. F. Wallace, B.Eng., Ph.D., at the Cadena Cafe, Cornmarket Street, Oxford. 7.15 p.m.

March 8

North Wales Metallurgical Society. (Joint meeting with Royal Institute of Chemistry, North Wales Section). "The Present position of Physical Chemistry in Steelmaking," by Sir Charles Goodeve, O.B.E., F.R.S., at Lecture Theatre, Flintshire Technical College, Connah's Quay, near Chester. 7.0 p.m.

Institute of Sheet Metal Engineering (Midland Branch). Annual General Meeting and Film Show, at the Midland Hotel, Birmingham. 6.45 p.m.

March 9

Liverpool Metallurgical Society. (Joint meeting with the Iron and Steel Institute). "Creep Deformation," by D. M. McLean, D.Sc., in the Dept. of Metallurgy, University of Liverpool. 7.0 p.m.

March 14

Institute of Sheet Metal Engineering, (South-West Branch). "Latest Developments in Gas Welding", in the Small Lecture Theatre, Engineering Laboratories, University of Bristol. 7.0 p.m.

March 15

North-East Metallurgical Society. "Properties of Metals at Very Low Temperatures," by C. J. Adkins, B.Sc., Ph.D., at Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough. 7.30 p.m.

Institute of Sheet Metal Engineering (North-West Branch). Annual General Meeting and Film Show, at the Manchester College of Technology, 7.0 p.m.

March 16

Birmingham Metallurgical Society (Inc.) and Institute of Metals (Birmingham Local Section). "Choosing a Stainless Steel," by H. T. Shirley (Firth Brown Research), at College of Technology, Gosta Green, Birmingham. 6.30 p.m.

March 20

Sheffield Society of Engineers and Metallurgists. "Technologists as Successful Managers," by R. Coverdale (Steel Co. of Wales Ltd.) at the Engineering Lecture Theatre, St. George's Square, Sheffield. 7.0 p.m.

March 23

Southampton Metallurgical Society. Annual General Meeting followed by "Metallurgy of Ferrous Welding," by R. G. Baker, Ph.D., M.A., at Southampton University. 7.15 p.m.

March 29

Institute of Sheet Metal Engineering (Wolverhampton Section). Annual General Meeting and Film Show, in the Wolverhampton and Staffordshire College of Technology, Wulfruna Street. 6.45 p.m.

IDEAL HOME EXHIBITION

THE Daily Mail Ideal Home Exhibition of 1961 will be held, as usual, at Olympia. It will open on March 7 and close at 10 p.m. on April 3.

A decorative theme, designed by Mr. James Gardner, O.B.E., R.D.I., will transform the Grand Hall into a scene of mythological grandeur dominated by vast fountains which will throw their jets of water almost to the roof of Olympia.

Changes of Address

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE CO. LTD. (a member of the BICC Group), 21, Bloomsbury Street, W.C.1, announce that the telephone number and inland telegraphic address are now MUSeum 1600 and "Telcon Phone, London" respectively.

The Sales Department of G. A. Harvey & Co. (London) Ltd. is now at Villiers House, Strand, London, W.C.2. Telephone: WHItehall 9931/7.

MEMBERS of the British Power Press Manufacturers' Association recently visited the Birkenhead factory of Moon Bros. Ltd. and during their tour inspected a new office block nearing completion which adjoins their factory and also saw some of the latest automatic drum-making plant. The illustration shows the group outside a Birkenhead country club after touring the factory—fourth from the left is Mr. R. B. Moon, managing director of Moon Bros. Ltd. and member of the council of the British Power Press Manufacturers' Association.

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NEW PLANT and EQUIPMENT

A monthly review of new machines, equipment, processes, etc., of interest to the producer and user of sheet metal

Open-back Inclinable Power Presses

DESIGNED by the Clearing Division of U.S. Industries, Inc., Chicago, U.S.A., Torc-Pac O.B.I. presses are now built in this country by Vickers-Armstrongs (Engineers) Ltd., Crayford, Kent. The modern design of these machines incorporates many unique features such as air safety clutch and brake in sealed unit, fabricated frame, eccentric drive. Sole Selling Agents in the United Kingdom are Rockwell Machine Tool Co., Ltd., Welsh Harp, Edgware Road, London, N.W.2.

Three models, of 22-, 32- and 45-tons capacity, are in production, the two smaller presses, which are powered by 2-h.p. and 3-h.p. continuously rated motors, being available with a choice of various fixed speeds or with variable-speed drives. Maximum speeds or these models are 225 and 150 s.p.m. The 45-ton capacity press is supplied with fixed speeds only, either 75, 90 or 122 s.p.m., drive being by a 5-h.p. continuously rated motor. All models can be furnished with any one of four stroke lengths, maximum being 4 in., 5 in. and 6 in. in relation to the press capacity. Standard or optional high bodies are available for all sizes and the 32- and 45-ton presses can be built with standard (8 in. or 9½ in.) or special (10½ in. or 12 in.) throat depths. Other variations can always be considered as the frame is fabricated.

Torc-Pac O.B.I. press frames are of all-steel welded construction to provide greater resistance to deflexion under load, the complete drive unit, including the flywheel, being situated between the frame side members. This results in a clean, compact design requiring the minimum floor space, *e.g.*, 28 in. × 39 in. for the 22-ton press when in the upright position.

The Torc-Pac drive unit incorporates an air-operated friction clutch and brake which never requires adjustment. The clutch and brake, flywheel bearings and gearing run in oil. The friction plates, which are of sintered bronze, are subject to much less wear than plates in an orthodox clutch unit as clutch engagement is started by trapped oil which is placed in shear. Furthermore, these special friction plates are not affected by high temperatures.

The clutch and brake are mechanically interlocked to prevent simultaneous engagement, air pressure releasing the brake and engaging the clutch. When air is exhausted, spring pressure releases the clutch and applies the brake. In the event of an air or electrical failure the press will come to a safe stop. The complete Torc-Pac drive unit is a sealed and guaranteed interchangeable unit which need never be opened by the user and an "off-the-shelf" replacement service is maintained.

From the clutch shaft the drive is taken through a reduction gearbox to a precision ground eccentric shaft running in anti-friction bearings, the bearing supports being immediately adjacent to the eccentric. This design eliminates all bending moments occurring in the orthodox crankshaft design. The shaft projects through the front housing to provide a power take-off for slide feeds, etc.

(*Continued in page* 234)

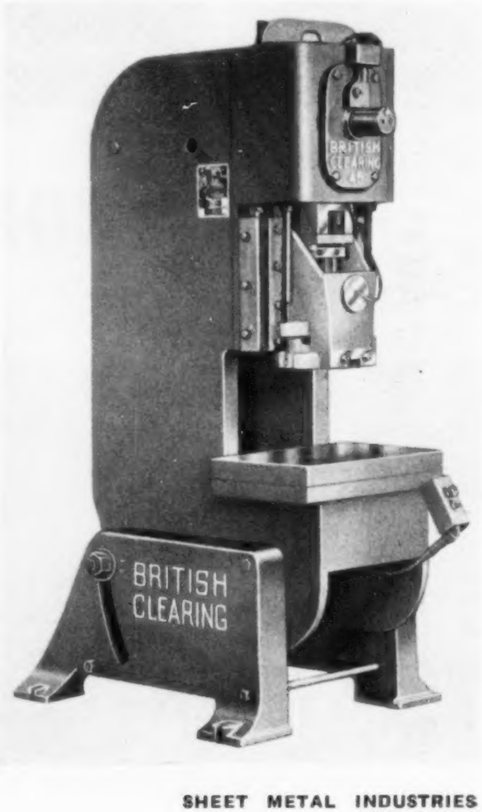
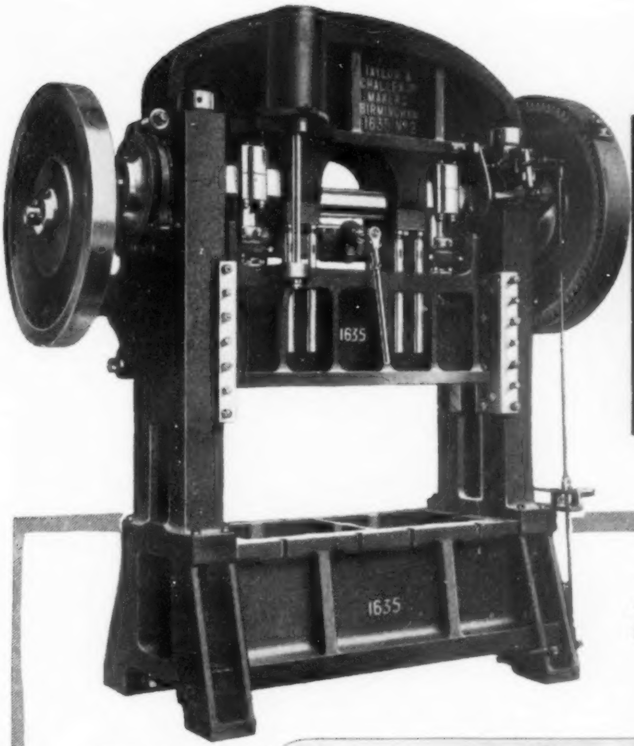


Fig. 1.—*45-ton power press*



DOUBLE CRANK PRESSES

150 ton Press, 10" stroke; 76" between uprights

WE ALSO MAKE

Power Screw Presses
Double Action type
Drawing Presses
Open-fronted Presses
Double sided Presses
All types of Automatic Feed Presses
Minting machinery
Cartridge machinery

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MEMBER

Fig. 2.—Torc-Pac drive unit

A stroke-indicating arrow shows the position of the eccentric. Fitted above the shaft extension is a limit switch operated by an adjustable cam for stopping the press at various speeds with the slide in the uppermost position.

The pitman has a forked lower end to which is fitted a thick plate. A pitman extension passes through this crosspiece and is locked in position by locknuts at top and bottom. The deep upper nut is calibrated in 0.001-in. divisions for fast, accurate slide setting, slide adjustment ranging from 2 to 2½ in. depending on the size of the press. This pitman design results in the tonnage being absorbed on all threads of the large adjustment nut, unlike the conventional split pitman design where the tonnage is concentrated on a few bottom threads.

The slide runs in vee ways with one fixed and one adjustable gib strip. The knockout bar is spring loaded in the top position for quieter operation.

Lubrication of the eccentric shaft bearings, pitman bearings and slides is from one point on the press frame by oil gun, manual pump or automatic pump.

Bed and bolster sizes for the three models are 21 in. × 11 in., 24 in. × 15 in. and 28 in. × 18 in. respectively. Bed openings are 9 in. × 5 in., 11 in. × 8 in. and 14 in. × 11 in. Plain bolster plates are supplied as standard but plates machined to customers' requirements can be provided.

Torc-Pac O.B.I. presses are easily inclinable by rotating an adjusting screw with a wrench. The 22- and 32-ton presses can be inclined up to 30 deg. and the larger model up to 25 deg.

A dust- and oil-tight cabinet containing the motor starter, control relays, transformer and fuses is mounted on the side of the press frame. The standard selector switch on the front of this cabinet has four positions: Continuous, Off, Inch and Once. Also available is the American Standard selector switch with an additional position adjacent to "Continuous" which gives "Machine continues to top of stroke."

Standard operator's controls consist of run and stop buttons mounted at the front right of the bed. Additional controls such as foot switches are available, these being simply plugged into the standard circuit. The control circuit operates on 110v.

Pneumatic die cushions are available for all models. Flanged slides with or without slide caps can be furnished on the 32 and 45 ton presses and adjustable air counter-balance cylinders are available for these models. Slide feeds, stock straighteners, reels, etc., are also available.

Air-operated Guillotine

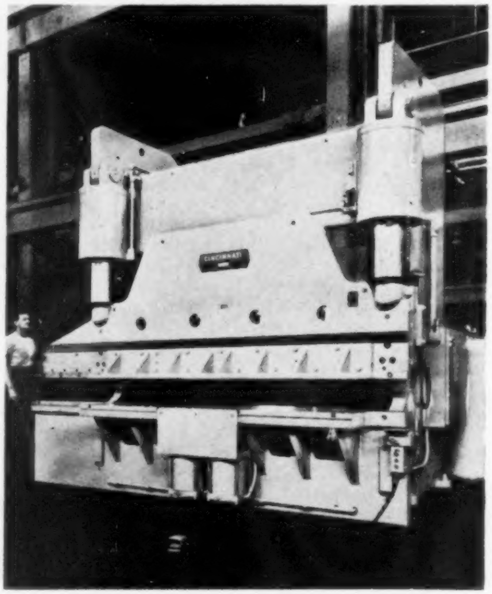
KEETON SONS AND CO., LTD., Sheffield, a member of the Firth Cleveland Group, have produced a "Keetona" air-operated guillotine which incorporates a 5-in. diameter Martonair cylinder for operating power, cutting 16 gauge (1.625 mm.) mild steel, aluminium, copper, or composition sheets up to 40 ft. by 50 ft. (1.000 m. by 1.250 m.). The remote control foot valve enables the guillotine to be operated from either side. Consumption is 15 cu. ft. per min. at 70/80 lb. per sq. in.

Hydraulic Press Brake

THE Cincinatti 300H hydraulic press brake shown in Fig. 3 can be utilized as both a punching and bending machine. Ram angle brackets combined with a permanently widened bed equipped with die cushions plus the extended bed and ram provide this press brake with exceptional versatility. For operator convenience, all machine controls are mounted at the right-hand end of the machine; two speeds to the ram offer both a fast pressing speed and a full tonnage pressing speed. The bending capacity is ⅜ in. by 10 in. mild steel, the distance between housings is 10 ft. 5⅜ in., total overall die surface is 15 ft., the stroke 18 in. and the throat 10 in. Other features include bottom of stroke control reading in thousandths and located in front of the machine convenient to the operator, automatic levelling control to ram with enclosed tape and direct acting Servo, ram tilt control reading in thousandths for fade out work and 30-h.p. electricals.

(*Continued in page* 236)

Fig. 3.—Hydraulic press brake



"FASTEX 5"

-the best electrode for most jobs

The Murex " Fastex 5 " electrode has many features which make it the best welding electrode for most jobs. It has exceptionally smooth running properties and general ease of operation in all welding positions. These are combined with low weld spatter and self-detaching slag. All these advantages ensure that high quality welds can be readily obtained for all general fabrication work, with neat and regular weld bead appearance and with freedom from undercut. Although primarily designed for flat and horizontal—vertical welding, the " Fastex 5 " electrode can be used in all other positions and is acknowledged by experienced engineers throughout the world as the best general purpose electrode for welding mild steel.

MUREX

MUREX WELDING PROCESSES LTD., WALTHAM CROSS, HERTS

T37

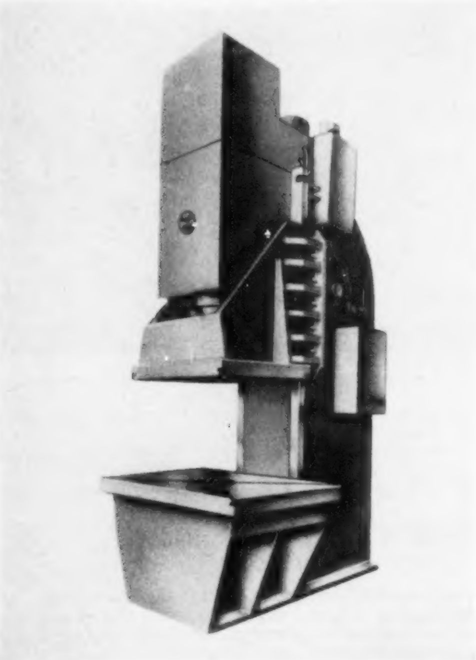
Hydraulic Press

A STEEL hydraulic press of Italian design and manufacture is available in this country through the sole distributors, Rushworth and Co. (Sowerby Bridge) Ltd., of Sowerby Bridge, Yorks. This is the OMF-Ferralba "Delta" type open-gap press (Fig. 4) which has a capacity of 250 tons with a table surface of approximately 51 in. × 40 in. and a stroke of 39⅜ in. Operating speed is 15 strokes per minute.

A 15-h.p. motor direct coupled to a multi-piston pump operates the hydraulic system which is provided with an automatic valve for quick filling and discharging of the cylinder during idle strokes and also with an adjustable slide stopping device. Control is either by push buttons mounted on the side of the upright which operate a servomotor, or by a manual control lever. The slide can also be controlled by means of push buttons on a pendant in front of the machine.

The maximum tonnage is exerted throughout the entire stroke and thus the necessity of vertical die adjustment is eliminated. A special design feature of the press is its delta shape which gives exceptionally good accessibility to the table and greatly facilitates the handling of bulky workpieces. High precision has been ensured by the provision of large surfaces for both piston and slides. The slides are protected by a steel guard.

Fig. 4.—Hydraulic press



An optional ancillary for this machine is an all-steel press-brake attachment which provides a maximum folding length of 9 ft. 10 in. Other optional extras are ejectors and a blank-holder under the table.

A smaller version of the same machine has a capacity of 150 tons and a table surface of 41 in. × 29 in. with a stroke of 27⅝ in. Speed of operation of this unit is 25 strokes per minute. The folding attachment for this model has a maximum length of 6 ft. 7 in.

The design and construction of the press are claimed to produce rapid and accurate forming, bending, straightening, embossing, trimming, punching, deep drawing and extruding operations.

Warning Device

A PHOTO-ELECTRIC device which will give warning of slowing down or stoppage of machinery used in continuous processes is produced by Hird-Brown Ltd., of 244 Marsland Road, Sale, Cheshire. The device, which can sense changes in rotation and other movement, is particularly useful where machinery is left unattended and can monitor machinery including conveyors, rotating shafts, fans, rollers, press rolls, reciprocating shafts, levers and crank arms. The unit is dust-tight for use in industrial conditions.

As there are no "make and break" contacts nor any mechanical connection with the monitored drive, installation is simple and no load is imposed on the drive. The unit has been designed to fail safe and to give an alarm should there be any component failure. The device is operated by repeated regular interruptions of a light beam which maintain a relay energized. Should the interruptions fall below a pre-determined speed or stop with the light beam broken or unbroken the relay will give an alarm or initiate correction. Magnetic sensing heads are also available.

Industrial Shaping and Trimming Tool

FIRTH CLEVELAND TOOLS LTD., the company in the Firth Cleveland Group which manufactures Surform hand tools and power tool accessories, have produced an industrial tool (Fig. 5), the purpose of which is to cut, smooth, shape and trim hard materials ; mild steel, aluminium, copper, brass, etc., and tests on a Herbert file-testing machine indicate that it will stand up to long periods of continuous use without impairing its efficiency. Its working surface, which for identification purposes is coloured blue, consists of a perforated blade of hardened and tempered Sheffield tool steel set with numerous scientifically-angled teeth. The body is of all-steel construction and has a removable forward guide ; alternative handles are available, No. 150 has a straight wooden handle and No. 151 has a cranked handle, which is adjustable through 360 deg. laterally with locating studs for positive positioning. All parts of the industrial tool are interchangeable, except the body, and are available separately. Special features of the tool are its balance, its efficiency when used with only a very light pressure and its ability to trim corners of hard materials without chattering or damage to the blade ; it is fast cutting and the perforations in the blade effectively prevent clogging.

Fig. 5.—"Industrial" tools

Electric Motors & Controls-2

Control equipment must enable the motor to be operated effectively, to obtain maximum productive efficiency. An outstanding advantage of individual electric drives is the flexibility of control available. Control equipment may be manual, semi-automatic or fully automatic, and includes gear for the following operations: starting, speed control (this subject will be dealt with in Data Sheet No. 16), reversing, stopping, switching off automatically if operating conditions become abnormal and isolation of motor and control equipment from the supply.

Every application of power has its own control requirements—and they are legion. Below are featured four uses of electric motors and their controls; they are given only as examples and represent but a small fraction of the whole picture.

Turret-lathe Control

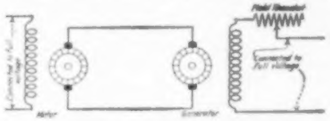
Various speeds are required for different tools, and it is possible to arrange, for instance, for a four-speed headstock, forward and reverse. By using a two-speed double-wound motor, eight speeds forward or reverse are obtainable. A dial on the headstock is set to the required speed and when a knob in the centre of the dial is pressed, the power-operated mechanism changes the speed of operation instantly.

Crane Control

This is a form of control which must be flexible yet completely foolproof. It is, for instance, possible to arrange for motor switching to be carried out by the contactors in response to movement of the crane driver's master controller. If the crane controller is moved quickly from the 'off' position to the 'last point lowering', the actual rate of acceleration is limited automatically by the relays. These also govern the retardation in order to prevent a heavy descending load being stopped too suddenly.

Planing-machine Control

Another example of motor control for machine tools is that for planing machines. For general workshop machining, the Ward-Leonard controlled motor, with a speed range of 10 to 1, gives a rapid and smooth reversal of the table travel and is ideally suited for short-stroke work. Two arrangements of Ward-Leonard control are available, the 3-machine



set with generator, exciter and driving motor, and a specially designed 4-machine set with an additional auxiliary exciter. With the 3-machine set the control equipment can include magnetic time relays which automatically adjust a regulator to strengthen the motor field at the instant of reversal and therefore greatly increase the accelerating torque. The auxiliary exciter of the 4-machine set automatically provides for the power input to the motor to be increased to give more accelerating torque at the instant of reversal.

Automatic Control

The control equipments described incorporate automatic features which help considerably towards obtaining safe and efficient operation of the driven machine, but much still depends on the human element. Braking equipment, for instance, cannot always become effective until an operative has taken some action. Devices, which will be described in other Data Sheets, 'observe' any abnormal condition and immediately and automatically initiate the braking system.

Particular attention should be paid to the positioning of controls. When a machine, or group of machines, requires a large number of push buttons and, in some cases, instruments etc., the controls can all be grouped on a desk with a mimic diagram, located in a position where the operator has full view of the work.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London W.C.2. TEMple Bar 9434.

They can offer you excellent reference books on electricity and productivity (8/6, or 9/- post free)—'Electric Motors and Controls' is an example.

E.D.A. also have available on free loan within the United Kingdom a series of films on the industrial uses of electricity. Ask for a catalogue.

7915/4

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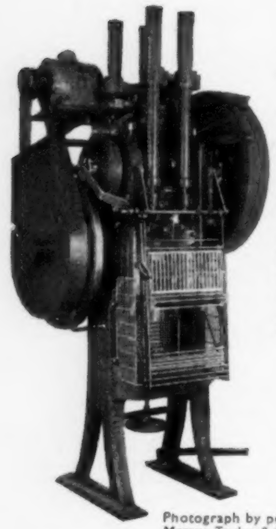

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Easy feeding through exceptionally large aperture with perfect safety for the operator who can close the "Camlock" guard either manually or automatically with the Newmatic Sequential Air Operation Unit. The Guard design avoids taking up tool space and large area top tools are accommodated. Interlocks are provided with the clutch and crank shaft.

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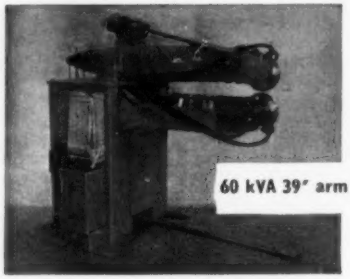

60 kVA 39" arm seam welder

Welds 16 gauge M.S. Sheets at 4½ ft. per min.

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- Variable mechanical pressure.
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ALSO PATENT SCALING MACHINES AND SPOT WELDERS

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39/6 EACH

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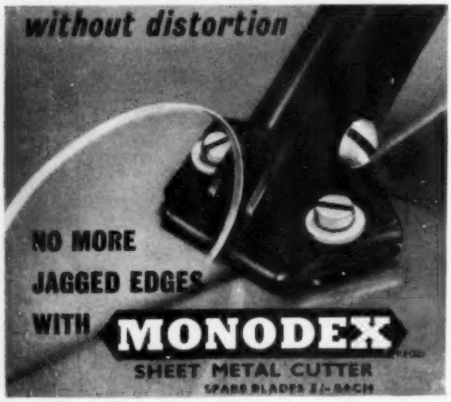

Patentools Ltd. Mitre House, Western Road, Brighton. Tel: Brighton 23580

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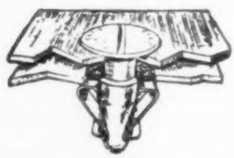

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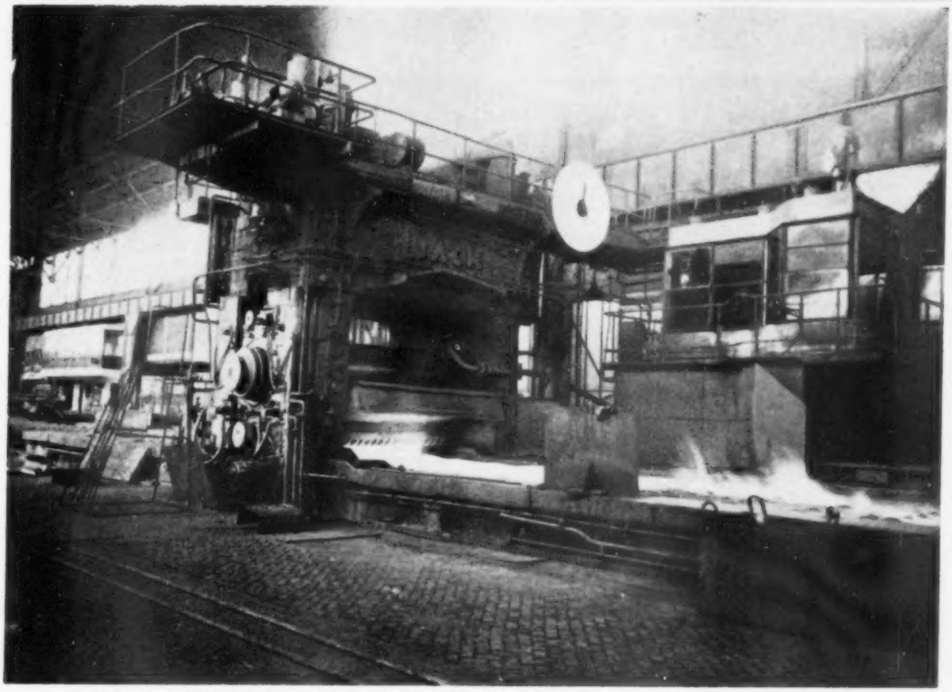

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WIRE or TAPE, Solid or resin cored
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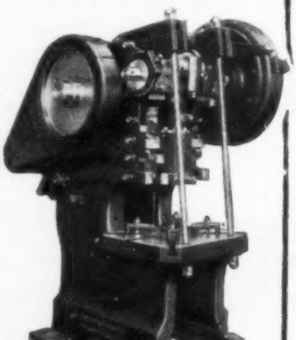

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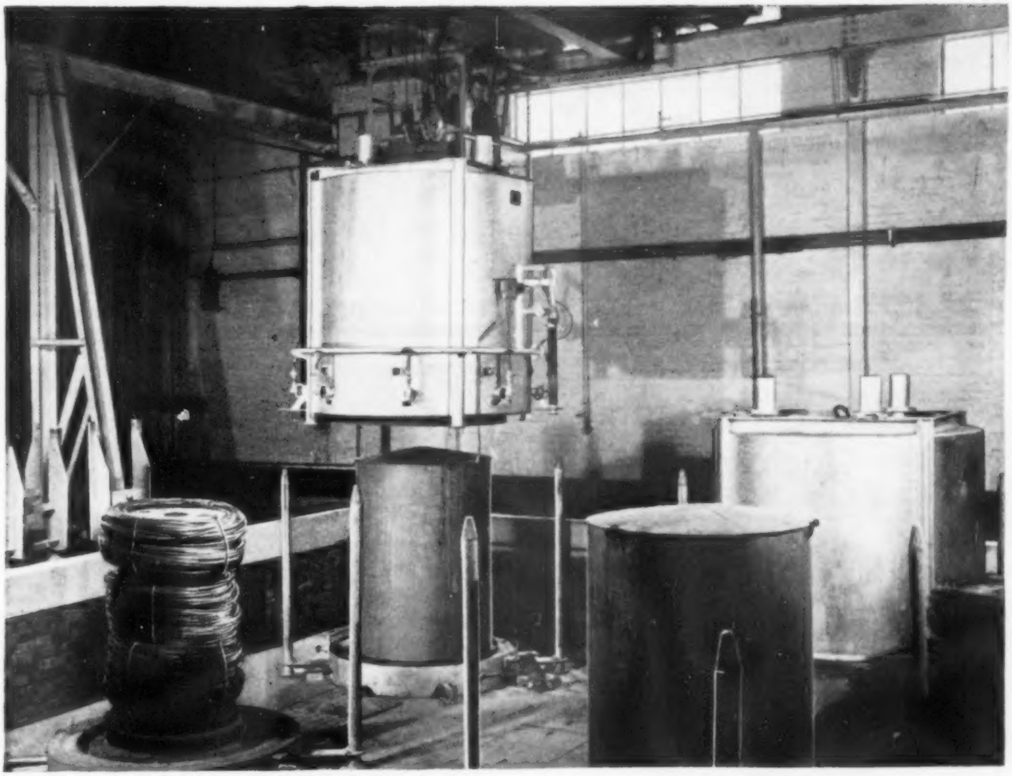

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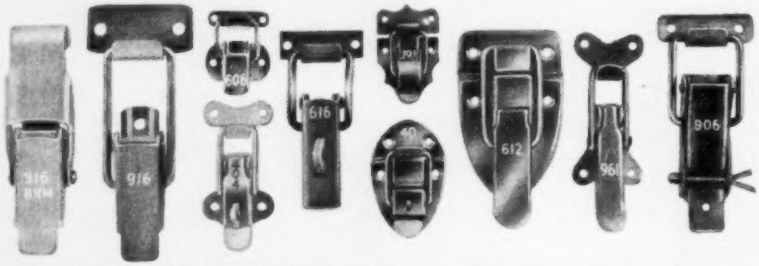

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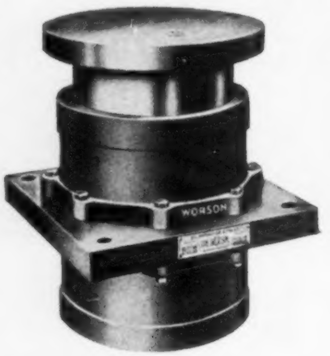

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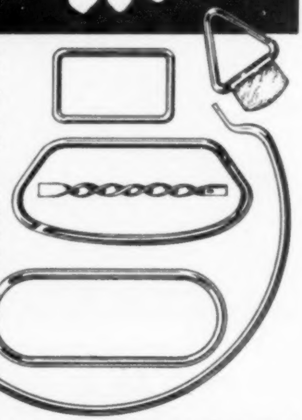

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Advertisements (accompanied by a remittance) and REPLIES TO BOX NUMBERS should be addressed to the Classified Advertisement Manager, "Sheet Metal Industries," John Adam House, 17-19, John Adam Street, Adelphi, London, W.C.2. Telephone: TRAfalgar 6171.

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TIN BOX Plant and Presses required suitable for round and irregular containers manufacture.—Modern Packages Ltd., Byass Works, Port Talbot, Glamorgan.

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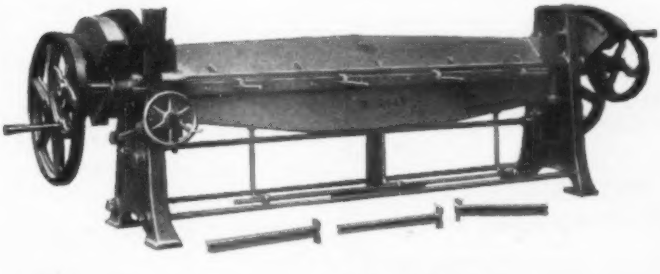

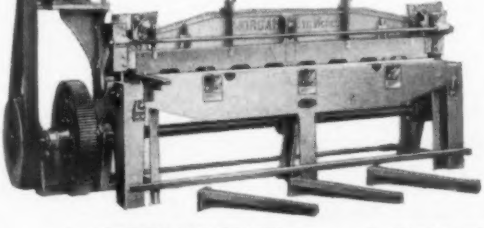

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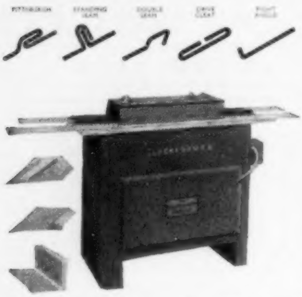

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47,500 SQ. FT. FLOORSPACE (mainly built 1957 - 1960)

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POWER PRESSES: (motorised) "Rhodes" 200 ton, 2 "Taylor and Challen" No. 370, "Edwards" 75 ton, "H.M.E." type OP75, 2 type OP30 and 2 type OP20, "Lecra" 60 ton and type OF 25 ton.

PRESSES: (hand) "B.N.L." No. 3B Arbor, Toggle, "Worcester" 6 ton and 5 Fly.

SHEET METAL MACHINERY: (mainly motorised) "Rhodes" 10 ft. Motorised HYDRAULIC PRESS BRAKE, No. 02 4 ft. Open-end OVERCRANK GUILLOTINE and 8 ft. Fluid Driven Shears, "Edwards" 4 ft. Cramp Folding, "Turner" Hydraulic Tangent Bending, "Rhodes" 30 in. Beam Folding, "Quickwork" No. 48L Stamping and Trimming, "Rhodes" No. 38 Angle Bending, "Frost" Grooving, "Besco" Swaging and "Lecra" type DP5 Rotary Seaming Machines, Bending Rolls 36 in. wide.

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Particulars of the premises and catalogues of the plant may be obtained from G. F. SINGLETON & CO., Industrial Auctioneers and Estate Agents, 9, Richmond Terrace, BLACKBURN (Tel. 7722/3) and Lloyds Bank Buildings, 53, King Street, MANCHESTER 2 (Tel. DEAnsgate 7954/8) or from the Liquidators, E. R. NICHOLSON ESQ., F.C.A., Messrs. Peat, Warwick, Mitchell & Co., 11, Ironmonger Lane, London, E.C.2 (Tel. MONarch 8888) and Vactric House, Sloane Street, London, S.W.1 (Tel. BELgravia 7000) or ARTHUR T. EAVES ESQ., F.C.A., Messrs. Harry L. Price & Co., 47, Mosley Street, Manchester 2 (Tel. CENtral 1905) or from the Solicitors, Messrs. GODDEN HOLME & CO., 5, Upper Belgrave Street, London, S.W.1.

SITUATIONS VACANT

(*See also page 113*)

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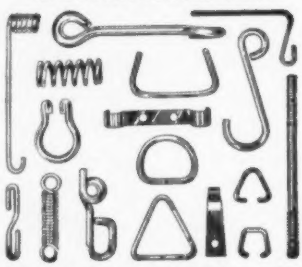

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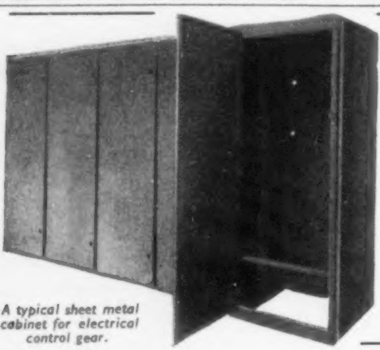

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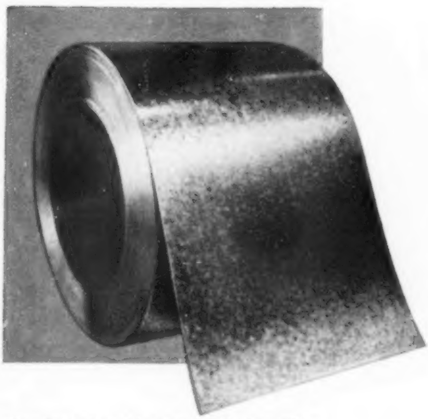

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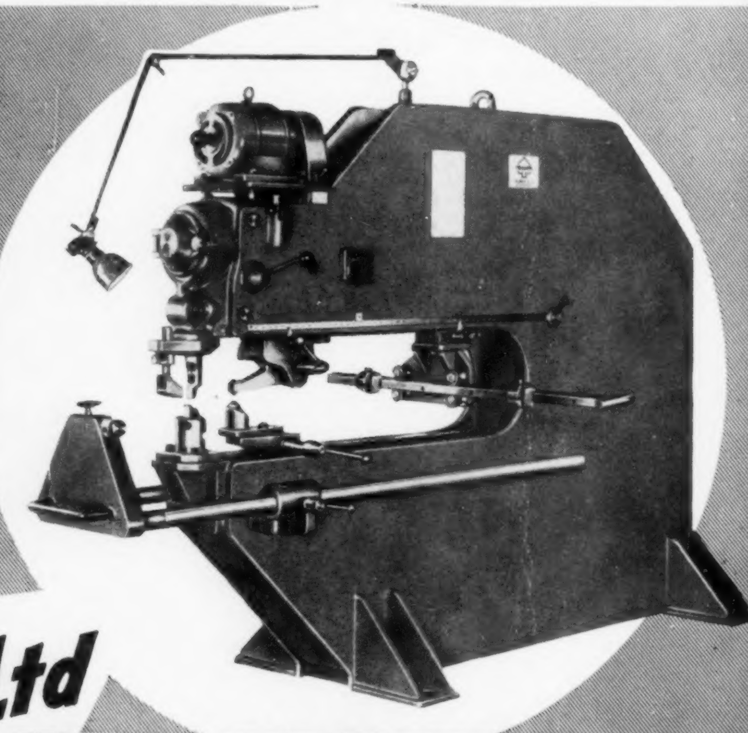

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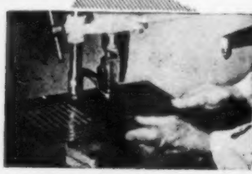
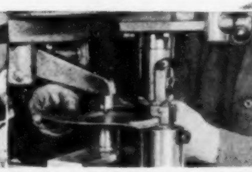
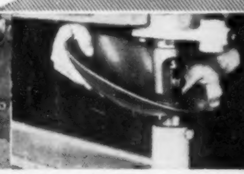


Cutting inside the sheet without starting hole, freehand or with straight or circle guiding attachment.



Working with the flanging tool and circle guiding attachment.



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